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ORIGINAL (Red)

Formerly Utilized MED/AEC Sites Remedial Action Program

Environmental Analysis of the Former Vitro Rare Metals Plant, Canonsburg, Pennsylvania

July 1979

Final Report

Prepared for

U.S. Department of Energy
Assistant Secretary for Environment
Division of Environmental Control Technology

Under
Contract No. EW-76-C-13-1658

By
Ford, Bacon & Davis Utah Inc.
SALT LAKE CITY, UTAH

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ABSTRACT

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The U.S. Department of Energy (DOE) has determined that the Former Vitro Rare Metals Plant at Canonsburg, Pennsylvania, is contaminated with radioactive residues resulting from previous uses of this property. This site was one of those identified for remedial action under the provisions of the Uranium Mill Tailings Control Act of 1978 (PL 95-604) and has been designated as required under this statute. Remedial action options are proposed in a companion Engineering Evaluation report. These options include stabilization of the contaminated areas within the site and removal of the contaminated materials to a remote disposal site. The objectives of this report are (1) to present the current radiological impacts on the environment due to the contamination, (2) to analyze the potential environmental impacts that may occur during the remedial actions, and (3) to present the potential changes in impacts once the remedial actions are complete.

The potential environmental impacts during implementation of the proposed remedial actions are generally short-term impacts. The potential for increasing ambient radiological levels and for further spreading of contamination during the remedial work suggests a short-term increase in potential health effects for workers involved in the remedial action efforts. In addition to radiological impacts, the remedial actions will have short-term impacts on traffic and noise, and potential impacts on air and water quality. When the proposed remedial actions have been completed, the impacts from radiation on the site will be reduced or eliminated.

It should be emphasized that this Environmental Analysis report is not an Environmental Impact Statement (for definitions see section 102 (2) (C) of NEPA). Also, this report does not meet the requirements of an Environmental Assessment report. The Environmental Analysis is an environmental report that identifies the environmental impacts of the proposed remedial action options presented in the Engineering Evaluation report. Radiation survey data used in this report were obtained from other sources.

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CHAPTER 1

INTRODUCTION AND BACKGROUND

CHAPTER 1

INTRODUCTION AND BACKGROUND

The United States Government has instituted a program known as the "Formerly Utilized MED/AEC Sites Remedial Action Program," or FUSRAP. This remedial action program for Manhattan Engineer District/Atomic Energy Commission Sites was initiated in 1974 by the AEC, continued under the Energy Research and Development Administration (ERDA), and is presently being managed by the Department of Energy (DOE). The objectives of this DOE program include determining the radiological conditions of former MED/AEC sites, identifying the options for remedial actions that could be undertaken along with their respective costs, and analyzing the environmental impacts of these actions.

Radioactive contamination above natural background levels has been measured at the former Vitro Rare Metals Plant in Canonsburg, Pennsylvania, which was an MED/AEC site. This site was one of those identified for remedial action under the provisions of the Uranium Mill Tailings Control Act of 1978 (PL 95-604) and has been designated as required under this statute.[1] Detailed descriptions of the radiological conditions at the Canonsburg site are presented in a report[2] prepared by the DOE's Oak Ridge National Laboratory (ORNL). Options for remedial action that could be undertaken at the site are described in a companion Engineering Evaluation report.[3]

1.1 PURPOSE

The purpose of this Environmental Analysis report is to present information regarding the existing environment and to analyze the potential environmental impacts that pertain to the present radiological conditions. Those impacts which might be associated with implementation of the various options for remedial action also are analyzed and presented.

If one of these options for remedial action is selected, this report could be used to determine whether additional environmental documentation would be required. This report is therefore developed in general accordance with the guidelines for an Environmental Assessment as described in 10 CFR 1021.12.

1.2 SUMMARY DESCRIPTION OF THE CANONSBURG SITE

The former Vitro Rare Metals Plant Site (i.e., the site, or the Canonsburg Site) is located in southwestern Pennsylvania in Washington County, within the Borough of Canonsburg, as shown in Figure 1-1. Canonsburg is approximately 20 mi southwest of downtown Pittsburgh, Pennsylvania. The site is divided into three parcels of land: Area A, Area B, and Area C. Chartiers Creek is adjacent to Areas B and C.

The Canonsburg site originally was operated as a radium :traction plant by the Standard Chemical Company from 1911 to)22.[2] Later, Vitro Corporation of America acquired the :operty and processed the on-site tailings to extract radium ıd uranium salts. From 1942 until 1957, Vitro was under ɔntract to the federal government to recover uranium from ore nd scrap. For the next 9 yr the site was used only for torage, under an AEC contract. Since 1967, the property has een owned by the Canon Development Company and is called he Canonsburg Industrial Park. The various buildings (8 tructures) on site are leased to tenant companies for light ndustry.

Processing of radioactive residues, scrap, and other ıaterial at the Canonsburg site by Vitro and later storage of :adioactive materials at the site from other MED/AEC facilities ɜventually led to contamination of the soil to various depths. The residues contained widely varying concentrations of radium, thorium, uranium, and other naturally occurring radionuclides. These residues have been detected over most of the site. Apparently all of the buildings in the Canonsburg Industrial Park are either built over or are adjacent to soils containing elevated quantities of radium.[2]

Surveys of the Canonsburg site were conducted by the ORNL,[2] the Environmental Measurements Laboratory (EML), the EG&G Energy Measurements Group, and Ford, Bacon & Davis Utah Inc. (FB&DU). These surveys, conducted on and around the site, provided the basic data on the radioactivity levels at the site. The surveys included all of the buildings and the yard area (18.6 acres). The surveys showed that the radiation levels measured in the soils and buildings are higher than the proposed DOE guideline levels for remedial action. Accordingly, engineering and environmental studies have been conducted.

1.3 BASIC OPTIONS FOR REMEDIAL ACTION

There are five basic options for dealing with radioactive contamination. These options are briefly described below. From these, six proposed options for remedial action were formulated in the Engineering Evaluation report.[3]

1.3.1 Option I - No Action

In this option, no action would be taken at all; i.e., the property would remain unchanged.

1.3.2 Option II - Minimal Action

Minimal action means that no action would be taken regarding the contaminants, per se. It would involve only measures which would effectively limit public exposure to radioactive sources, such as restricting access to a contaminated property.

1.3.3 Option III - Stabilization or Entombment

Stabilization refers to the in situ (in place) covering of a contaminated area of ground with compacted clean fill. Stabilization with at least 2 ft of compacted clay materially reduces the radon emanation and external gamma exposure from the contaminants. Entombment involves the total encapsulation of contaminated material by a permanent casing, such as concrete.

1.3.4 Option IV - Partial Decontamination

Partial decontamination involves action toward reducing active or potentially active sources of further contamination, such as partial removal of material. In buildings, for example, transferable alpha contamination might be cleaned up or covered over with an epoxy film to check its spread. Radon gas and radon daughter concentrations can be reduced to appropriate levels by ventilation, filtration, or other methods. Restrictions on access to the site may be required.

1.3.5 Option V - Decontamination and Restoration

Decontamination and restoration are taken to mean that all contaminated materials would be removed from a property. The razed contaminated buildings, and excavated soils and debris would be transported to an appropriate disposal site. Upon decontamination, the property would be restored by backfilling and seeding or by landscaping, and the property would be available for unrestricted use.

The proposed DOE decontamination criteria for excavation of soils are:

Criterion A - Decontaminate to radium ^{226}Ra concentration of 5 pCi/g above natural background levels

Criterion B - Decontaminate to natural radium background level for the area (approximately 1.2 pCi/g)

Although these criteria are applicable at the time of remedial action, where feasible the soils may be removed to less than 5 pCi/g. This would meet the ALARA (as low as reasonably achievable) philosophy.

The five basic options (I-V) include the range of options considered for the Canonsburg site. The differing conditions on three areas of the Canonsburg site do not permit a selection of any one of the basic options. Instead, six options for remedial action are presented in the companion Engineering Evaluation report[3] which combine the most practical basic options for each site area.

.4 PROPOSED OPTIONS FOR REMEDIAL ACTION

Table 1-1 presents the actions associated with each of the proposed options for remedial action. It includes a list of the major tasks in sequential order of implementation. Prior to taking any action, the labor force will be trained to work with contaminated materials and special equipment. In addition, detailed engineering and radiological monitoring plans will be developed. Radiological surveys will be conducted during and after remedial action activities to ensure that the remedial action criteria are met and that airborne contaminant levels do not exceed applicable standards. The options that follow are proposed for remedial action at the Canonsburg site.(3)

1.4.1 Option A - No Action

In this option, no action would be taken; i.e., the property would remain unchanged. This option is one of the possible courses of action that requires consideration. Inclusion of this option also is necessary so that the impacts of the current conditions can be compared with the impacts from other options.

1.4.2 Option B - Minimal Action

Minimal action would not reduce the contamination; however, it would limit exposure of employees and the public by preventing access to the contaminated areas. The site would not be usable for any purpose.

Option B requires that the property be: (a) purchased by a government agency and held in perpetuity, (b) controlled by fencing and posted with appropriate warning signs, (c) maintained, and (d) radiologically surveyed periodically (assumed to be semiannually for cost estimating) for land and water pollution until it is determined that contamination is not migrating from the site. Monitoring wells would be installed for sampling of ground water. Each of the three areas of the site would be fenced. Approximately 30 working days would be required for implementation of this option.

1.4.3 Option C - Stabilization of All Areas without Removal of Buildings in Area A

Stabilization would be achieved by applying compacted clean fill (preferably clay) over the contaminated areas of the site. A 2-ft depth of clean fill could reduce external gamma radiation to natural background levels, and radon flux by about 25% to 90%, depending upon the type of fill used.(4) Up to 6 in. of topsoil could be needed for water retention and rooting of grass seeds. The stabilized area would be fertilized, mulched, and seeded. A seed mixture would be formulated that would result in a maintenance-free ground cover. Water sprays would be implemented to control dust.

The building roofs would be sealed to prevent the spread of contamination. A drain system would collect water from the buildings to prevent erosion of the stabilizing materials. Ground level openings would be sealed to prevent the intrusion of fill material. The developed portion of Area A containing the buildings would be fenced to block access to the structures. Areas B and C would be available for restricted use not involving excavation or construction of buildings. The estimated time required to implement Option C is 60 days.

Semiannual radiological surveys and water sampling of monitor wells would be necessary after the remedial action to detect any ground water contamination and to ensure the continued effectiveness of the stabilization.

1.4.4 Option D - Stabilization of All Areas with Removal of Buildings in Area A

The actions for Areas B and C in this option would be the same as for Option C. In Area A, however, the buildings would be demolished and buried on site. Area A then would be stabilized and vegetation planted, but would not be fenced. It would be available for restricted use not involving excavation or construction of buildings. Approximately 90 days would be required for implementation of Option D.

Semiannual radiological surveys and sampling of monitor wells would be necessary after the remedial action to detect any ground water contamination and to ensure continued effective stabilization and maintenance of the site.

1.4.5 Option E - Decontamination and Restoration of Part of Area A; Stabilization of Area B and Remainder of Area A; Decontamination and Restoration of Area C

The developed portion of Area A containing the buildings would be decontaminated and restored. Buildings would be razed and buried, since decontamination of the structures would be too costly. Many of the structural components and steel columns could be decontaminated and salvaged if the buildings were demolished.

The contaminated soils from the developed portion of the site would be excavated to the prescribed decontamination criterion. The contaminated soils and building debris would be buried between Areas A and B, and Ward Street would be relocated within Area A. The decontaminated portion of Area A would be backfilled and restored for possible commercial or industrial use. Area B and the remainder of Area A would be stabilized as described for Option C.

Area C would be excavated to the prescribed decontamination criterion. The contaminated soils would be excavated using conventional equipment down to where soil becomes softened by ncreased water content. The wet soil may require the use of ackhoes and draglines. It may be necessary to pump water from he excavation; if the water were contaminated, it would be vaporated or disposed of in an approved manner.

The excavated soils from Area C would be transported to a remote disposal site. The high moisture content and high radioactivity of the soils preclude on-site disposal. The excavated area would be backfilled and restored.

Monitor wells would be installed to detect any contamination of ground waters. Semiannual radiological surveys would be needed to ensure the continued effectiveness of the stabilization. It is estimated that 120 days would be needed to complete this remedial action option. The decontaminated areas (Area C and part of Area A) would be available for unrestricted use. Stabilized areas (Area B and part of Area A) would be available for restricted use.

1.4.6 Option F - Decontamination and Restoration of Entire Site

All three areas of the site would be decontaminated. The buildings in Area A would be razed. All contaminated materials would be excavated to meet the prescribed decontamination criterion, loaded into trucks or railcars, then shipped to a remote disposal site. The Uranium Mill Tailings Radiation Control Act of 1978[1] calls for the state to assess in-state locations for use as a disposal site. A remote disposal site at a distance of 100 mi from Canonsburg is therefore considered. Also, an example of a remote site for estimating maximum cost might be the federally owned Nevada Test Site (NTS) located 65 mi northwest of Las Vegas, Nevada, about 2,400 mi from Canonsburg.

The excavated area of the Canonsburg site would be backfilled with the clean overburden and imported clean fill. The site then would be contour-graded. Topsoil would be applied to disturbed portions of the site, then seeded to establish an erosion-resistant ground cover. The operations involved would be basically the same as described for Area C, above.

Radiological surveys would be conducted during and after remedial action activities to ensure that the decontamination criterion was met and that airborne contaminant levels did not exceed applicable standards. The entire site would be available for unrestricted use.

1.5 APPROACH TO IMPACT ANALYSIS

This report covers the analysis of the possible environmental impacts of the existing radiological conditions at the Canonsburg site and the impacts associated with implementing the proposed remedial action options presented in the Engineering Evaluation report.[3]

The current conditions described in Chapter 2 form the bases for the analysis of the present impacts described in Chapter 3 under Option I. Also included in Chapter 3 are the impacts that occur during and after implementation of the proposed options for remedial action. A discussion of the environmental tradeoffs of each remedial action option in terms of advantages and disadvantages is presented in Chapter 4. A summary of data from the Engineering Evaluation report[3] is listed in Table 1-2. These data are used throughout this report to quantify risks, particularly in Chapter 3.

Reference is made in this report to radiation measurements and contaminated materials at off-site locations in and around Canonsburg. These materials and locations, including the creek and land adjacent to the site, are to be evaluated and analyzed in separate reports.

A glossary of technical terms is included in Appendix A. Health impact calculations are shown in Appendix B.

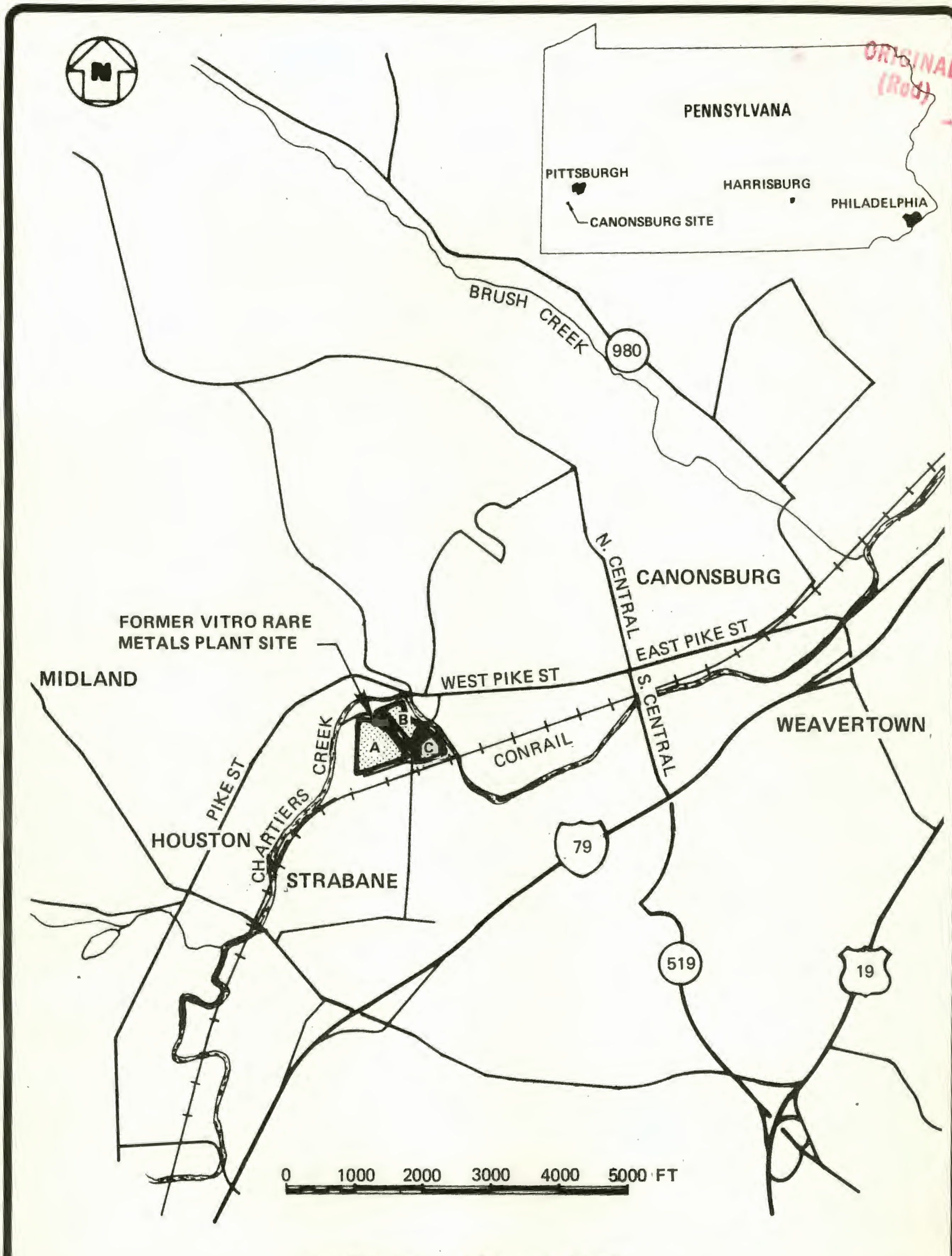

FIGURE 1-1. VICINITY MAP

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TABLE 1-1

ACTIONS ASSOCIATED WITH PROPOSED OPTIONS FOR REMEDIAL ACTION AT THE FORMER VITRO RARE METALS PLANT

PLANNING AND TRAINING[a]

1) Formulate remedial action specifications and plans

   a) Perimeters of contamination
   b) Depth of contamination

2) Mark contaminated areas

3) Train labor force to work with contaminated materials and special equipment when required

OPTION A[b] - NO ACTION

No action involved

OPTION B - MINIMAL ACTION

1) Governmental agency acquires site

2) Control site access by installing fence around each area; site not available for any use

3) Post warning signs

4) Drill and case sampling wells for ground water surveys

5) Maintain site indefinitely and perform semiannual surveillance and radiological monitoring

OPTION C - STABILIZATION OF ALL AREAS WITHOUT REMOVAL OF BUILDINGS IN AREA A

1) Governmental agency acquires site

2) Prepare buildings

   a) Seal roofs
   b) Install roof drain collection system
   c) Block ground level openings

3) Cover areas of surface contamination

a) Clear areas to be stabilized
b) Haul, spread, and compact cover material to conform to predetermined grading plan

4) Perform radiological surveys during and after remedial actions to assure that measures are taken to prevent the spread of contamination and to verify that decontamination conforms with preestablished criteria

5) Restore site with topsoil and plant with suitable grasses to stabilize cover material

6) Control access to portion of Area A containing buildings by installing fence; fenced area unavailable for any use; stabilized areas could be available for restricted use, such as recreation

7) Drill and case sampling wells for ground water surveys

8) Maintain site

a) Site use restrictions are maintained indefinitely by governmental agency
b) Perform semiannual radiological surveys of site and maintain as required

OPTION D - STABILIZATION OF ALL AREAS WITH REMOVAL OF BUILDINGS IN AREA A

1) Governmental agency acquires site

2) Demolish buildings in Area A

3) Bury building rubble on site

4) Cover areas of surface contamination

a) Clear area to be stabilized
b) Haul, spread, and compact cover material to conform to predetermined grading plan

5) Perform radiological surveys during and after remedial actions to assure that measures are taken to prevent the spread of contamination and to verify that decontamination conforms with preestablished criteria

6) Restore site with topsoil and plant with suitable grasses to stabilize cover material

7) Drill and case sampling wells for ground water surveys

8) Maintain site

   a) Site use restrictions are maintained indefinitely by governmental agency. Site available for restricted use, such as recreation

<u>OPTION E - DECONTAMINATION AND RESTORATION OF PART OF AREA A; STABILIZATION OF AREA B AND REMAINDER OF AREA A; DECONTAMINATION AND RESTORATION OF AREA C</u>

1) Governmental agency acquires site

2) Decontaminate and restore part of Area A

   a) Demolish buildings
   b) Excavate to selected decontamination criterion and bury with building debris between Areas A and B
   c) Backfill and restore excavations

3) Relocate Ward Street to decontaminated part of Area A

4) Stabilize Area B and remainder of Area A

   a) Clear areas to be stabilized
   b) Haul, spread, and compact cover material to conform to predetermined grading plan
   c) Restore with topsoil and plant with suitable grasses

TABLE 1-1 (Cont)

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5) Decontaminate and restore Area C

   a) Clear site
   b) Strip and stockpile overburden
   c) Excavate to selected decontamination criterion and transport to remote disposal site
   d) Restore by backfilling, topsoiling, and seeding disturbed area

6) Perform radiological surveys during and after remedial actions to assure that measures are taken to prevent the spread of contamination and to verify that decontamination conforms with preestablished criteria

7) Drill and case sampling wells for ground water surveys

8) Maintain site

   a) Restrictions on stabilized portions of site are maintained indefinitely by governmental agency. Decontaminated areas of the site could be made available for unrestricted use
   b) Perform semiannual radiological surveys of site and maintain as required

<u>OPTION F - DECONTAMINATION AND RESTORATION OF ENTIRE SITE</u>

1) Governmental agency acquires site

2) Clear contaminated areas

   a) Clear site
   b) Strip and stockpile overburden

3) Excavate to the selected decontamination criterion; transport contaminated soils and debris to a remote disposal site by truck or rail

4) Perform radiological surveys during and after remedial actions to verify that decontamination activities meet the preestablished criterion, that measures have been taken to prevent the spread of contamination, and that airborne contaminants do not exceed existing criteria

TABLE 1-1 (Cont)

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5) Restore site

   a) Contour to preestablished grading plan, utilizing stockpiled overburden and clean fill
   b) Apply topsoil and plant with suitable grasses to stabilize disturbed area

6) Site would be available for unrestricted use

---

[a] All options will incorporate appropriate planning and training. Typical planning and training steps for Option F are listed here and are not repeated under each option.

[b] This involves no action but is included here in order to present a complete table of the options.

TABLE 1–2
SUMMARY OF DATA FROM ENGINEERING EVALUATION OF THE FORMER RARE METALS PLANT CANONSBURG, PENNSYLVANIA

OPTION	SURVEYED SEMI–ANNUALLY	NUMBER OF WORKING DAYS (NO. OF EMPLOYEES)		VOLUME OF CONTAMINATED MATERIAL REMOVED (Yd^3)		VOLUME OF CLEAN COVER OR FILL (Yd^3)		COST (IN THOUSANDS OF 1979 DOLLARS)	
A: NO ACTION	—	—		—		—		—	
B: MINIMAL ACTION	YES	30 (20)		—		—		200	
C: STABILIZATION	YES	60 (35)		—		59,000 (4,200)a 80,000 TONS		760	
D: RAZE BLDGS. & STABILIZATION	YES	90 (35)		—		66,000 (4,700)a 89,000 TONS		1,215	
		5 pCi/g	BKGD	5 pCi/g	BKGD	5 pCi/g	BKGD	5 pCi/g	BKGD
E: PARTIAL DECONTAMINATION & STABILIZATION	YES	120 (35)f	130 (35)f	42,000 (3,000) 57,000 TONS	48,000 (3,400) 65,000 TONS	98,000 (7,000) 130,000 TONS	104,000 (7,400) 140,000 TONS	1,525b 1,844c 2,298d 9,169e	1,620b 1,983c 2,502d 10,344e
F: DECONTAMINATION & RESTORATION	NO	150 (35)f	180 (40)f	123,000 (8,800) 170,000 TONS	146,000 (10,400) 200,000 TONS	123,000 (8,800)	146,000 (10,400)	2,245b 3,195c 4,520d 25,045e	2,468b 3,586c 5,182d 29,300e

NOTES:
1. HAUL DISTANCE OF CLEAN COVER OR FILL = 25 Mi
2. 1 ACRE = 4840 yd^2
3. 2Ft COVER = 60,000 yd^3 TO COVER 18.6 ACRES
4. AVERAGE DENSITY OF OF SOIL = 100 Lbs/Ft^3 = 1.35 $TONS/yd^3$
5. NUMBER OF ACRES TOTAL = 18.6
   AREA A = 11.0
   AREA B = 4.5
   AREA C = 3.1

a. NUMBER OF TRUCKS @ 14 yd^3/TRUCK TO HAUL MATERIAL IS SHOWN IN PARENTHESES.

b. COSTS THAT DO NOT INCLUDE TRANSPORTATION COSTS OF CONTAMINATED MATERIAL TO A DISPOSAL SITE.

c., d., e.= COSTS THAT INCLUDE TRANSPORTATION COSTS TO DISPOSAL SITE.
- c. 100 MILES AWAY, BY RAIL
- d. 100 MILES AWAY, BY TRUCK
- e. 2400 MILES AWAY, BY RAIL

f. THE NUMBER OF EMPLOYEES SHOWN FOR OPTIONS E & F DO NOT INCLUDE TRUCK DRIVERS AS DO OPTIONS C AND D.

CHAPTER 1 REFERENCES

ORIGINAL (Red)

1. "Draft Generic Environmental Impact Statement on Uranium Milling;" NUREG-0511; Vol II Appendices; U.S. Nuclear Regulatory Commission; Washington, D.C.; Apr 1979.

2. "Formerly Utilized MED/AEC Sites Remedial Action Program, Radiological Survey of the Former Vitro Rare Metals Plant, Canonsburg, Pennsylvania;" DOE/EV-0005/3; ORNL; Oak Ridge, Tennessee; Apr 1978.

3. "Engineering Evaluation of the Former Vitro Rare Metals Plant, Canonsburg, Pennsylvania;" FBDU 230-002; Ford, Bacon & Davis Utah, Inc.; Salt Lake City, Utah; July 1979.

4. R.F. Overmyer, V.C. Rogers and C.M. Jensen; "Reduction of Radon Flux from Uranium Tailings;" Ford, Bacon & Davis Utah, Inc., Salt Lake City, Utah; paper presented at the American Mining Congress; Las Vegas, Nevada; Oct 9-12, 1978.

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CHAPTER 2

DESCRIPTION OF EXISTING ENVIRONMENT

CHAPTER 2

DESCRIPTION OF EXISTING ENVIRONMENT

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The purpose of this chapter is to describe the present conditions and environment of the Former Vitro Rare Metals Plant site. The presence of radioactive contamination at this site may result in long-term health impacts. Several options for remedial action have been formulated either to contain or to remove the contaminated materials. To analyze the environmental impacts due to the radioactive contamination and those associated with the proposed options for remedial action as presented in Chapter 3, a physical description of the site area is given in this chapter. The present physical environment is examined in terms of topography, geology, hydrology, meteorology, and ecology. The socioeconomic factors of the site and vicinity, the future growth, and the economic potential also are discussed. A discussion of the present radiation environment of the site is presented and compared with natural background radiation levels and with DOE-proposed radiation guidelines.

2.1 DESCRIPTION OF THE FORMER VITRO RARE METALS SITE

The site is located in north Washington County within the corporate limits of Canonsburg, Pennsylvania. The property is located at the intersection of George Street and Strabane Avenue. It is bounded on the east by Chartiers Creek, on the south by George Street and the ConRail right-of-way (formerly Penn-Central Railroad), on the west by private property, and on the north by the Washington-Canonsburg Street Railway right-of-way. These features can be seen on Figure 1-1 in Chapter 1, and on Figure 2-1. The site is designated as: Parcel Nos. 1, 2, and 3 of DBV 1162, P. 331, in the Borough of Canonsburg, County of Washington, State of Pennsylvania.

The entire site area is comprised of an 18.6-acre tract. The site is divided into three parcels: Area A, consisting of 11 acres contains the 8 structures that comprise 14 buildings; Area B, consisting of 4.5 acres, containing no structures; and Area C, consisting of 3.1 acres, with an unused baseball field located upon it. An overhead powerline crosses Areas A and B in a generally north-south direction. Figure 2-2 is a photograph of the site. Figure 2-3 shows the utilities, building locations, fences, and other major site features.

The sections that follow are descriptions of the three distinct site areas designated as Areas A, B and C.

2.1.1 Area A

Area A consists of 11 acres and includes the highest ground and all the buildings on site. Improvements on Area A onsist of 8 distinct structures designated by 14 building umbers. Some of the structures were formed by adding new buildings to existing buildings, then giving the addition a new building number. Other numbered buildings were constructed by building between existing buildings to form one continuous structure. Several structures have only one building number. The structures and building numbers are shown in Figure 2-3. These buildings total approximately 105,900 ft^2 with a total volume of approximately 1,496,100 ft^3. At present, all commercial activity on site is confined to Area A. Buildings 4, 12, and 14 were in existence in 1956 but do not now exist, except for their foundations, concrete floors, and some remaining rubble. Buildings 5 and 17 no longer exist nor are their past locations known. Building 13 was renumbered as Building 18. Buildings were constructed on concrete slabs which are still intact. Three of the buildings have two floors. A more detailed description of each building is presented in Reference 1.

The original Vitro era buildings that remain are generally two-story buildings constructed of structural steel frames and of concrete floors and ceilings; all have concrete block exteriors, which are curtain or nonbearing walls. Structurally, the old buildings are in excellent condition in spite of their exterior appearance.

The newer buildings (constructed since 1967) are in excellent structural shape. They generally follow the same type of construction as the older buildings, except that precast concrete roof panels were used on flat-roofed buildings and that some of the buildings are constructed of corrugated asbestos or metal siding instead of concrete block. The fit-into-place construction used to erect the buildings and the lack of maintenance have made the entire complex appear substandard.

Buildings on the site presently house metal fabrication operations, chemical packaging operations, a trucking company, a laundry, and a few small warehousing and wholesaling companies. Most of the buildings include one or more offices.

Buildings in Area A are supplied by natural gas, water, and electric power. A sewerline, not connected to any building, runs into a septic tank north of Building 16. Within Area A there are a series of railroad spurlines which are operable but presently inactive. In many places these lines are buried by gravel pavement. Concrete slabs in the area are remnants of old building and structure foundations, sidewalks, and driveways; others are loading docks or covers for old pits. Many of the yard areas around the buildings are covered with old building debris and other debris principally consisting of scrap metal from previous manufacturing operations in the areas along the west property line and north of Buildings 16 and 19. Old concrete tank foundations also are located north of Building 16. There is evidence of a yard drainage system with catch basins, most of which are now plugged with dirt. The areas around the buildings generally are covered with gravel. There is no asphalt paving on site.

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Most of Area A is enclosed by a 6-ft-high chainlink fence topped with three strands of barbed wire. The fence is rusted and broken in many places. Some small trees grow in Area A, but most are located outside the fenceline.

2.1.2 Area B

Area B, consisting of 4.5 acres, is land upon which materials dredged from Chartiers Creek have been placed. The area is graded relatively flat and slopes toward Chartiers Creek on its northeastern edge. There are no fences or structures, but an overhead powerline crosses the area in a generally north-south direction. There are trees and other natural vegetation in this area. At present, the area is not being used.

2.1.3 Area C

Area C is roughly triangular in shape; it consists of 3.1 acres and represents the area of lowest elevation of the site. The surface is nearly flat and is bounded by chainlink fence on the south and west, and by Chartiers Creek on the east. This area originally was used as a storage lagoon for liquid wastes from processing operations. In 1965, it was used as a disposal area for decontamination of Area A. It was stabilized and graded. There are trees and other natural vegetation in this area. For a time this area was used as a ballpark, but now is not in use.

2.2 PHYSICAL ENVIRONMENT

The description of the physical environment includes the topography, geology, hydrology, meteorology, and ecology.

2.2.1 Topography

The entire site area slopes to the east toward Chartiers Creek from 998 to 967 ft above sea level. It is in the drainage basin of Chartiers Creek, which discharges into the Ohio River west of Pittsburgh, approximately 15 mi to the north of Canonsburg.[2,3]

The industrial park is located on the highest portion of Area A, between elevations of 992 and 998 ft above sea level. The relatively flat surface of Area B is about 978 ft above sea level, and Area C has a gradual elevation decline toward Chartiers Creek to an approximate elevation of 967 ft above sea level. Figure 2-3 is a descriptive map of the site and includes the topography of the site.

.2.2 Geology

The unconsolidated materials at the site, represented by the Carmichaels Formation and the alluvial deposits, are of relatively recent fluvial origin. Underlying these deposits is the Conemaugh Formation of the Pennsylvanian System. The sedimentary strata of this system consists primarily of sandstones with some conglomerate (gravels), shale, limestone, clay, and numerous beds of coal. Presently, only one of these beds of coal, the Pittsburgh coal, is of economic value,(4) and thus, may represent some future basis for excavation and extraction in this general area.

The Washington Formation and the Monongahela Formation, which contains the Pittsburgh coal at its base, can be seen as outcrops in the surrounding hills. Figure 2-4 shows these rock units. The underlying bedrock at the site is the Conemaugh Formation, which is predominantly shale with abundant sandstone beds and some limestone, clay, and coal.(4)

All of the formations in the area were laid down in nearly horizontal layers by a vast inland sea which covered the area during prehistoric times. They subsequently were tilted slightly in a northeast-southwest direction. This southwesterly dip is modified by gentle anticlines, synclines, and other structural features. The Washington Anticline, running northeast-southwest, is to the southwest of the site and can be seen in Figure 2-4.(5,6) The present land surface was formed by stream erosion of a former plainlike area.

The Canonsburg site is in an area where the history of the soils is closely associated with a fluvial environment. The original soils at the Canonsburg site were a mixture of the upland slope and the stream-deposited soils surrounding the site. However, these original soils have been disturbed by urban development. The Greene and Washington Counties Soil Survey, Soil Conservation Service,(7) has classified the site and much of the surrounding area as "urban land". Indentification of the soils comprising urban land would require careful on-site investigations because of disturbance of the original soil types by removal or covering with fill materials.

The Rainsboro and Melvin soils in the site area noted in Figure 2-5 were formed as deposits of Chartiers Creek. The Rainsboro soils, formed in old terrace deposits, are not as subject to flooding as are the Melvin soils which form on the flood plains. The remaining surrounding soils all are formed in place from weathered bedrock on the upland slopes, or from weathered materials at the foot of slopes.(7) Figure 2-6 shows the distribution of soil types in the site vicinity.

Table 2-1 indicates the properties of the different soil types. The dominant soil types of the area are silty loams or silty clay loams that vary from 1 to 6 ft over the bedrock. The common characteristics of the upper soil types include shallow to steep slopes and a high water table that occurs during the spring and autumn months. Other soil type characteristics vary; e.g., drainage varies from poor to moderately well, and permeability varies from slow to moderately rapid.[7]

2.2.3 Hydrology

The hydrology of the site environment is a significant factor in determining the feasibility of stabilizing the radioactive waste on site. A fundamental characteristic of an acceptable option for remedial action is the assurance that emplaced wastes will not result in the spread of contamination through ground and surface waters. The hydrologic characterization is concerned with the features that are broadly descriptive of surface water and ground water resource quality, quantity, and usage, as well as the surface-water features (e.g. flooding) that might restrict the site's use for some of the proposed options for remedial action.

Surface Water

There are abundant surface waters in the area including several streams, intermittent drainages, reservoirs, and ponds. Surface waters in the vicinity of the site include Chartiers Creek and several ditches which carry runoff. Although Chartiers Creek flows southward on the east of the site, its predominant direction of flow is northeasterly through a meandering, partially filled valley. Chartiers Creek joins the Ohio River 2.6 mi downstream from the point where the Monongahela and Allegheny Rivers merge to form the Ohio River.

At a gaging station about 12 mi northeast of Canonsburg in Carnegie, the average flow of Chartiers Creek is 287 ft^3/sec.[8] The estimated average flow of Chartiers Creek in Canonsburg is between 90 and 130 ft^3/sec. During a September 1912 flood, flows of 8,500 ft^3/sec in the Canonsburg-Houston area and 20,000 ft^3/sec in the Carnegie area were recorded. The extent of this flood is shown in Figure 2-6. This intensity of flooding in the area is estimated to have a recurrence interval of about 52 yr. However, the completion of a flood control project[9] in the area should reduce this frequency to once every 600 yr. When this project is completed, flooding will have very little effect on the site.

The surface contour in the site vicinity and the drainage ditches limit flow of off-site waters onto the site. A ridge of dirt and debris along the western fence prevents off-site waters from this direction from flowing through the site. A ditch along George Street collects off-site waters from the south. Although some off-site waters do come on site from the south, they are confined to two drainage ditches on either side of Strabane Avenue. A ditch along the northern fenceline collects runoff from that direction.

The source of most of the on-site waters is the precipitation which falls directly onto the site. These waters generally flow from the site to drainage ditches along the sides of Areas A, B, and C, then eventually into Chartiers Creek. For instance, most of Area A drains into ditches along Ward Street and George Street, into a ditch west of Strabane Avenue, then into Chartiers Creek. Runoff from Area B flows into either Chartiers Creek or into a ditch east of Ward Street, and then into Chartiers Creek. Most of the runoff from Area C goes directly into Chartiers Creek, but some flows into a ditch west of Strabane Avenue and some into a ditch east of the area, and then into Chartiers Creek. There is some ponding of water on the site during and after precipitation. Ponding is especially noticable in Area A between the buildings, and some ponding occurs on the flat surfaces in Area B. Since vegetation is established over most of the site, there is little ongoing erosion from these areas. Some erosion of soils occurs on the northwest section of Area A near the road leading to Ward Street.

The quality of water in Chartiers Creek is poor because of acid-water drainage from mines and release of municipal and industrial sewage. Surface water accounts for over 94% of water used by public water supply facilities in the area of the site, but no water is drawn from Chartiers Creek.[10] Public water generally is supplied by reservoirs behind storage dams on the smaller streams. Water also is drawn from the Ohio River downstream from the confluence of Chartiers Creek and the Ohio River.

Ground Water[8]

Ground water in Washington County occurs in unconsolidated deposits and in bedrock aquifers. Confined ground-water systems in the Conemaugh Formation underlying the site occur largely in sandstone beds. Limited quantities occur in bedding-plane passages and in joint planes of the shales and limestones. Water in the confined aquifers at the site moves to the south-southeast down the plunge of and towards the Ninevah Syncline. Because of underlying shale beds, any water recharging this aquifer would be confined to the upper layers of the Conemaugh Formation. Water in these beds might be under artesian pressure since it generally is confined by less permeable materials. The aquifer is not tapped heavily in this area. Consequently, the hydraulic gradient would be upward in this area, preventing ground water at the site from recharging the aquifer.

There is little use of ground water aquifers in Washington County. More than 80% of the county population receives water from public supply facilities, which obtain 94% of their water from surface supplies.[8] However, some rural residents in the area do rely on wells for water supplies. Figure 2-6 shows the only well within a mile of the site which is recorded with the Pennsylvania Department of Environmental Resources.[11]

While this map shows only one well within a 1-mi radius from the site, all wells are not reported and wells drilled before 1965 were not recorded. There may be several other wells in the outlying areas.

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2.2.4 Meteorology

The climate in the site vicinity is an important part of the overview of the environment. The potential for leaching and site erosion depends on the potential for precipitation and flooding. Wind conditions, topographic effects, and atmospheric dispersion and transport conditions are important factors in characterizing the impact of radon releases from this site.

The Canonsburg site is approximately 17 mi south of a full weather station at the Pittsburgh airport and approximately 6 mi from a station kept by private and government agencies at Washington, Pennsylvania. Weather data used in this analysis have been gathered over a 19-yr span at the Pittsburgh airport and for 50 yr in Washington. Weather data have been recorded in Pittsburgh for 104 yr, beginning in 1874. Data from these stations, if interpreted with care and if average seasonal variations are considered, can be used to estimate meteorological conditions within the region of the Canonsburg site.

The normal annual temperature is 53.9 °F with monthly normal temperature ranging from 75.4 °F in July to 33.3 °F in January. The average frost-free period in the basin is 150 days. The site is in an area of variable air mass activity and is subjected alternately to polar, tropical, continental, and maritime air mass invasions. Weather change is usually gradual, occurring within 5 to 10 days. Occasionally the passage of fronts causes rapid and more frequent changes. Stagnation of air masses over longer periods occurs infrequently.[12]

The average annual precipitation based on the 97-yr records has been 36.87 in. at Pittsburgh, and 37.07 in. for the 50-yr records kept at Washington, Pennsylvania. The average monthly precipitation at Pittsburgh has been a maximum of 3.95 in. during June and a minimum of 2.31 in. during February. In Washington, a maximum average of 4.22 in. has occurred in June and a minimum average of 2.38 in. in November. Summer rains usually are the result of brief convectional storms of high intensity. There have been 10-in. to 12-in. rainfalls in several hours unofficially recorded in the stream basin north of Canonsburg. Precipitation occurring in the fall, winter, and early spring is more general and more moderate in intensity. Average annual snowfall in Pittsburgh is 33.7 in. For the period 1953 to 1968, a maximum of 14.4 in. of snow fell in a single snowstorm. Snow cover is generally not continuous through the winter.[12]

Prevailing winds are from the southwest, or have a westerly component, and have a mean speed of about 10 mi/hr. Maximum elocities of about 70 mi/hr have been recorded for short urations. In the past 17 yr, 8 tornadoes have occurred in outhwestern Pennsylvania. Figure 2-7 shows the wind rose for the area.[12]

2.2.5 Ecology

Vegetation is established over most of the site. Old field-type vegetation is found in Area B. Area C primarily contains grasses. Along Chartiers Creek in Areas B and C there are small trees, shrubs, and other vegetation; and there are birds and small mammals associated with old field and creek bottom habitats.

Flora

The most commonly observed plants growing on the site include various grasses, weeds, seedlings and young plants of various annual species, cat-tails, and other perennial plants which thrive in marshes and low areas that may be inundated from time to time. The species that comprise most of the flora of the area are given in the following list by their scientific name:

Poa pratensis
Hordeum jubatum
Atriplex patula
Typha latifolia
Types augustifolia
Bromus sp.
Rumix crispus
Rumex salicifolius
Pastinaca sativa
Dactylis glomerata
Barbarea vulgaris
Stellaria media
Solanum dulcamara
Plantago lanceolata
Oenothera sp.
Lactuca scariola
Convolvulus sp.
Vitis sp.
Polygonum sp.
Melilotus alba
Alopecurus sp.

There is no currently available information on the presence of any specific endangered, rare or threatened plantlife species in the area or vicinity of the Canonsburg site.

Fauna

Because of the area's heavy industrial activities, wildlife on the Canonsburg site and in the surrounding area is not abundant except for rodents, some reptilian and avian species, and fresh water fish. No studies have been undertaken to ascertain whether any endangered, threatened, or rare wildlife species are present in the site vicinity.

2.3 SOCIOECONOMIC FACTORS OF THE CANONSBURG SITE AND VICINITY

The distribution of population is a significant parameter in assessing a variety of potential impacts on people and their activities from the site in its present condition, and during and after implementation of the proposed options for remedial action. Population-density data are used to indicate potential radiological impacts.

The Canonsburg site lies entirely within the Borough of Canonsburg, Washington County, Pennsylvania. Houston Borough is west, Chartiers Township is north, and North Strabane Township is south of the site. These political jurisdictions and major transporation routes are shown in Figure 2-8. Located within a 5-mi radius of the site are two counties and numerous smaller political subdivisions.

This area developed originally as farming communities contained within the stream valleys. From 1860 to 1910, the development of railroads along Chartiers Creek and the discovery of coal and oil in the area prompted rapid growth and a change of many communities to urban and industrial ways of life. With the national shift from coal to gas and petroleum fuels, the economy of the area declined.

2.3.1 Present Population

Populations in Canonsburg and Houston have been declining for the past 20 yr; however, as a result of recent flood control measures and urban renewal programs, this trend may reverse. The recent completion of Interstate 79 also has been stimulating growth in the area. It is possible, however, that the population within a mile of the site could decrease based on past trends in the Canonsburg and Houston areas and on the relatively unstable industrial economic base. Consequently, a population of 6,500 is assumed to be the lower limit. There are approximately 5,000 people employed at firms located within a 1-mi distance from the site; most of these employees are located in Canonsburg. For purposes of health effects calculations, the residential population in 16 sectors within 0.5, 0.75, and 1 mi of the site, as shown in Figure 2-9, were estimated from a count of residences within each sector. The residential population within 1 mi of the site is estimated to be approximately 8,100 people living in 2,300 dwellings.

2.3.2 Land Use and Population Growth Potential

As shown in Figure 2-10, the area near the Canonsburg site is a mixture of industrial, commercial, public, and residential land. Commercial and industrial businesses are located along Chartiers Creek, the railroads, and Pike Street. Future land use is likely to involve the development of rural and vacant lands for residences and industrial businesses, and the concentration of commercial enterprises which are now scattered along Pike Street and throughout the towns. The land use plan for Canonsburg calls for the development of a homogenous, light-industrial use of the areas north and west of the site.[13,14]

The future demographic and economic conditions of the area can be projected on the basis of past trends and on assumptions concerning future economic conditions.(13,14) Changes in residential, commercial, and industrial populations can be expected within a mile from the site over the coming years. Residential population projections and employment outlooks are shown in Figure 2-11. Employment figures for the area were based on a fraction of those people employed in Canonsburg, Houston, Chartiers, and North Strabane. A maximum population of 15,000 within 15 yr might be attained within a mile of the site, if the construction of medium-priced and high-rise apartments should occur in this part of the countyside. It is not likely that this maximum growth will be attained and an increase to 11,000 people appears to be a more realistic figure.

2.3.3 Economic Potential

According to real estate brokers in the vicinity, the location of the site appears ideal for the purpose for which it is being used. However, rail service and fairly convenient freeway access, coupled with housing areas nearby, make the site area suitable for real estate development. They indicate that the 11-acre plot in Area A could be worth approximately $28,000 to $32,000/acre, if the radioactive contamination problem were resolved and if present buildings were not on the site. This would increase the value of the site to approximately $330,000. Because of the contamination within the buildings, their real current market value would be difficult to obtain. The buildings and site have poor physical appearance and show lack of maintenance. It is estimated that the current total worth of the buildings in their existing conditions (not considering radioactive contamination) is approximately $1,300,000. Replacement cost of the footage and volume of the existing buildings is estimated to be $2,500,000.

Areas B and C, with a total of about 7.6 acres, are of much less value because of the unstable soil conditions and the potential flood danger. Their use for structures is marginal, even if the contamination were removed. The value of Areas B and C is associated with their suitability for greenbelt or for community recreational areas. In a contamination-free condition, their total value would approximate $10,000/acre for a total of $76,000 for the entire acreage.

Therefore, total current market value of the entire site including structures, assuming there were no contamination problems would be $1,706,000 (i.e. $330,000 for land Area A, plus $1,300,000 for buildings, plus $76,000 for land of Areas B and C). Figures do not include the value of the equipment nor the furnishings within the buildings.

The presence of contamination on site has had no effect on real estate values surrounding the site. The Borough of

Canonsburg has imposed no building restrictions on surrounding properties.

2.4 RADIATION ENVIRONMENT OF THE SITE

Following is a description of the radiation environment of the Canonsburg site. As an introduction to this description, radiation hazards to man and exposure mechanisms are discussed to facilitate understanding of the present conditions. A discussion of proposed radiation exposure guidelines also is given, followed by a summary of radiation measurements which include natural background measurements.

2.4.1 Radiation Hazards to Man and Exposure Mechanisms

There are naturally occurring radionuclides present in minute quantities throughout the environment. Radiation from these sources and cosmic radiation constitute "background radiation exposure." Background exposure from natural background radiation can be altered by man's actions at a given location; for example, by laying topsoil of different radionuclide content, building a house of "cool" wood or "hot" brick, etc.

Natural Radioactive Elements

The principal isotope of uranium is uranium-238 (^{238}U), which undergoes radioactive decay to a new element at a characteristic rate called the half-life. The daughter product of this decay is itself radioactive, giving rise to a series or chain of subsequent radioactive decays. The uranium chain includes ^{230}Th (thorium), ^{226}Ra (radium), ^{222}Rn (radon), and radon daughter products. This chain finally ends at a stable, nonradioactive isotope of lead. While most members of the chain (e.g. uranium, radium, and lead) are chemically reactive solids, radon is a chemically inert gas. Radon therefore tends to emanate from the earth in areas where uranium and radium are present. Although these radionuclides occur in nature, their concentrations in uranium ore are several orders-of-magnitude greater than in average natural soils and rocks. These radionuclides are the principal products of concern in this report and represent the contaminants considered for remedial actions at the Canonsburg site.

The types of radiation that result from decays within the ^{238}U chain are called alpha (α), beta (β), and gamma (γ) radiations. The biological effects of radiation are related to the amount of energy that is deposited within the body (either on the body surface or internally) by alpha particles, beta particles and gamma rays. The types of radiation emitted by some of the members of this chain are included in Figure 2-12, although not all members of this decay chain are shown in this figure.

Radon tends to concentrate in buildings which do not have adequate ventilation. In locations where uranium and radium are concentrated, such as natural uranium ore bodies or at mill tailings piles, concentrations in air of radon and radon daughters can occur well in excess of proposed DOE guidelines. This mechanism also produces radon concentration levels in areas of trace quantities of uranium in soil, but concentrations of concern generally do not occur.

Pathways of Radiation to Man

Some of the mechanisms by which radioactivity from uranium reaches man also are illustrated in Figure 2-12. There are two primary means by which people are exposed to the radiation: by taking radioactive material into the body and by being exposed to highly penetrating gamma rays. The first of these is divided into ingestion (which means eating contaminated foods or drinking contaminated liquids) and inhalation (which here refers to the breathing-in of radioactive material).

Ingestion of radioactive material takes place in two principal ways: by drinking water that contains leached radionuclides such as radium, and by eating food that has been grown in contaminated earth or that has radioactive dust on its surface. Food plants may take up radioactive material while growing in contaminated soil. Consumption of meat from cattle that have grazed on contaminated forage is another ingestion pathway.

Radioactive materials may be trapped in the lungs by inhalation of radon daughters produced by the decay of radon in the air. A very small fraction of radon inhaled decays in the lungs and is retained as radon daughters.

Inhalation of radioactive particulates may occur if dust is picked up by mechanical activities or by wind from areas that do not have a ground cover. Dust, which can increase radiation exposure, may be expected from any excavation; however, dust control procedures would be employed during any remedial action work.

Gamma rays, known to be highly penetrating, are similar in effect to X-rays and may cause damage to any part of the body. Gamma radiation from uranium ores and residues arises mainly from decay of ^{214}Bi.

Radiological measurements provide an indication of the amount of radiation that is being transmitted via food, air and water pathways. Such measurements generally are conducted on background samples in the vicinity of a site to establish background concentrations of radionuclides for comparison with measurements on or near the site.

Calculation of Health Effects

Radioactive exposure from materials containing uranium and its decay daughters occurs from the absorption within the body of emitted alpha and beta particles and gamma radiation. The biological effects of radiation are related to the type and energy of the radiation. The dose from radiation is measured in terms of the energy deposited per unit mass of material. One rad is the dose that corresponds to the absorption of 100 ergs/g of material. The relative amount of damage caused by a given amount of energy from the different types of radiation is called the "quality factor." The equivalent dose, in units of rem, is the product of the energy deposition in rads and the quality factor. In this analysis, a gamma exposure of 1 R in air is assumed to be equivalent to a dose of 1 rem in soft tissue.

Radiation exposure from ^{222}Rn daughters is expressed in terms of the working level month (WLM), which is equivalent to exposure to a radon daughter concentration of 1 WL for 170 hr. The definition of a WL is given in Appendix A. Total population exposures and health risks from ^{222}Rn daughter inhalation are based upon these units instead of the rem.

The methodology used in estimating the dose rates and health effects (potential cancer cases) associated with the radioactive contamination is given in Appendix B. The following risk estimators are used to obtain the number of potential health effects:(15)

^{222}Rn daughters - 180 effects per 10^6 person WLM total cumulative exposure

external gamma - 100 effects per year for 10^6 person-rem continuous exposure to gamma radiation

These are absolute risk estimators rather than relative risk estimators, and are based on exposure to the particular radiation source for a lifetime.

It should be emphasized that a projected cancer rate does not mean that a cancer case will occur in a given number of years, or that any one case can be attributed specifically to radon daughter inhalation. All that can be stated is that an individual's risk is increased by his exposure to radon daughters (or other ionizing radiations such as diagnostic X-rays) and that the total cancer rate to a given population may be expected to increase with such exposure.

2.4.2 Proposed Radiation Exposure Guidelines

The use of radioactive materials and radiation-producing machines for scientific, industrial, and medical purposes causes exposure to workers in industry and to the general public. Scientifically based guidelines have been developed to place an upper limit on such exposures. The limits established for exposures to the general public are much lower than those established for workers in the nuclear industry.

The DOE Division of Operational and Environmental Safety has drafted the following proposed remedial action guidelines.[16] (These guidelines have been used to indicate the radiation level at which remedial actions are indicated until such time as applicable federal guidelines are received from the EPA.):

Type of Measurement	Remedial Action Indicated If Radiation Level Exceeds
Radium in soils	0.02 WL above natural background (5 pCi/g above natural background)
Radon daughter concentration	0.02 WL above natural background
External gamma exposure rate	170 mR/yr above natural background (20 μR/hr) for continuous exposure; 80 μR/hr for occupational exposure (2,000 hr/yr)
Transferable alpha	20 dpm/100 cm^2

The remedial action guideline value for radium in soil is based upon a limit of 0.02 WL above natural background for radon daughter concentration in a structure on the contaminated area. This working level limit has been related to a radium concentration in soil of 5 pCi/g above natural background to an infinite depth.

Measured average background levels in the Canonsburg vicinity are given in Paragraph 2.4.3. For simplicity, the conservative value of 5 pCi/g above natural background is used for ^{226}Ra concentration in contaminated soil for remedial action.

2.4.3 Radiation Measurements and Natural Background Radiation Levels

This section compares the natural background radiation levels with those levels measured on and around the Canonsburg site. The measurements are summarized in this section, but are reported in detail in other documents.[1,17-19]

The average natural radiation background levels in the Canonsburg area are:

^{226}Ra in surface soil	1.2 pCi/gm
^{226}Ra in water	0.4 pCi/l
^{222}Rn concentration in air (outdoor)	0.3 pCi/l
Radon daughter concentration (indoor)	<0.01 WL
Outdoor gamma exposure rate	11 μR/hr

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As reported by ORNL, most of the buildings in the Canonsburg Industrial Park exhibit levels of radiation that exceed DOE proposed guidelines for remedial action. Gamma radiation levels up to 30 times natural background values (310 μR/hr) have been measured in the buildings. Radon daughter working levels of approximately 70 times those found in the vicinity also are reported by ORNL. Radon concentrations in buildings on site range from 2 to 107 pCi/l, or about 100 times natural background levels. Water samples were taken from drains in Buildings 1, 2, 10, 11, and 18 and from a large pit below Building 19. Only three of these samples had ^{226}Ra concentrations(1) approaching the maximum permissible concentration (30 pCi/l) listed in 10 CFR 20, Appendix A.

Areas A, B and C of the site contain surface and subsurface soil contamination that produces gamma radiation levels above natural background levels.(1) Surface concentrations of ^{226}Ra as high as 4,200 pCi/g have been measured. External gamma radiation levels of 1,600 μR/hr are reported by ORNL investigators.(1) Several ground water samples obtained from drill holes on the site contained ^{226}Ra concentrations exceeding the maximum concentration for ^{226}Ra in water.

Off-site radiation levels that exceed natural background levels have also been reported by ORNL. Gamma radiation levels of several times natural background were reported at nearby off-site locations. In an area south of the site a single gamma reading of 2,000 μR/hr was reported. Soil samples were obtained off-site, particularly along the banks of Chartiers Creek, that gave ^{226}Ra concentrations up to 100 times the natural background level (1.2 pCi/g of ^{226}Ra). Radon concentration measurements in several nearby off-site indoor locations and one outdoor location ranged to several times natural background and appeared to be attributable to the contamination from the site. Three outdoor radon measurements at 400 ft from the site boundaries averaged 0.5 pCi/l at each location.(1) These values are less than twice the natural background radon concentration in the Canonsburg vicinity. Four water samples taken from Chartiers Creek upstream and adjacent to the site contained 0.5 pCi/l or less of ^{226}Ra, well below the EPA Drinking Water Regulations.

A summary of some of the radiation measurements at the site is listed in Table 2-2. Off-site radiation levels are referred to at different points in this report and are to be analyzed and evaluated in separate reports.

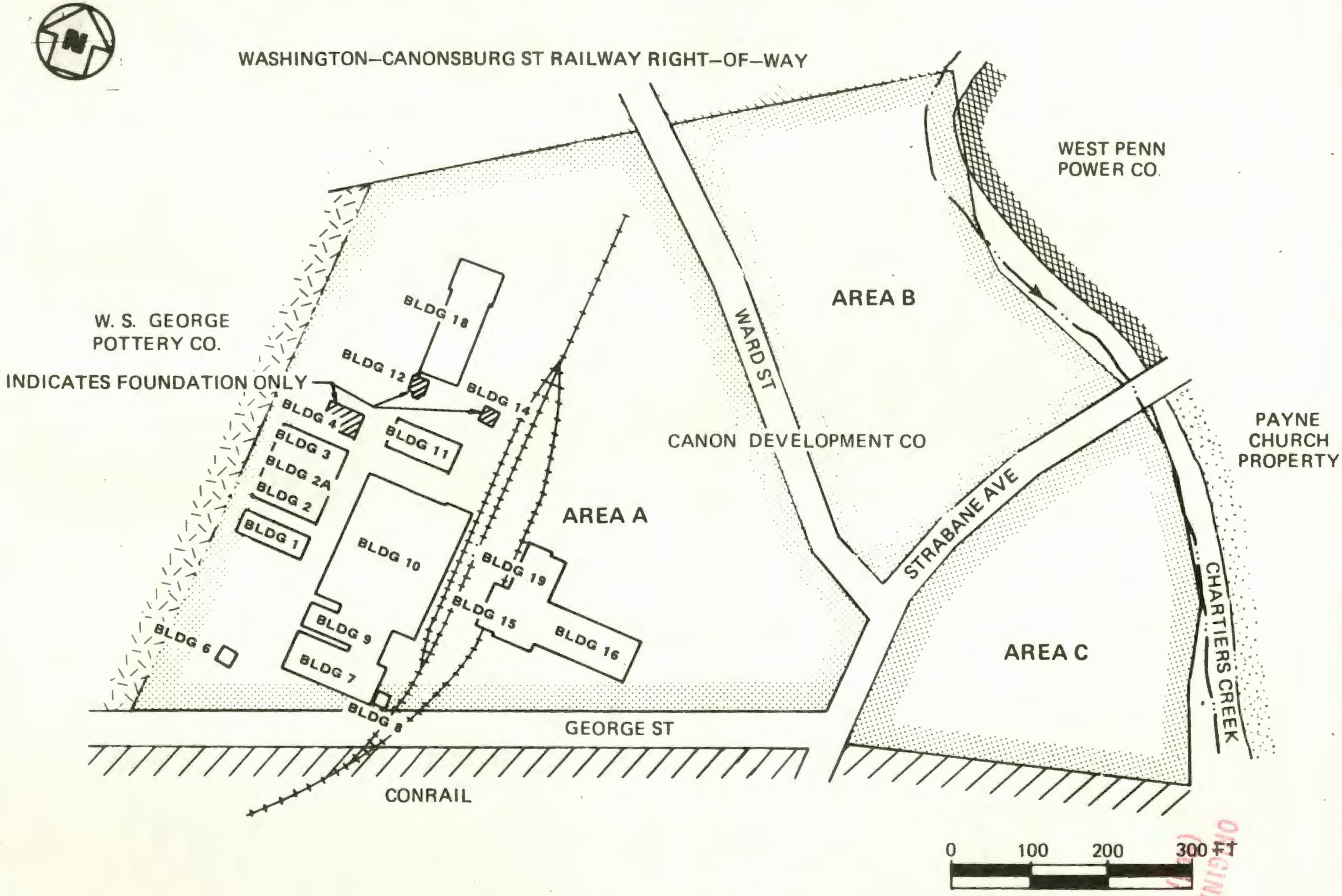


FIGURE 2-1. LAND OWNERSHIP

230-006

Ford, Bacon & Davis Utah Inc.

FIGURE 2-2. SITE MAP

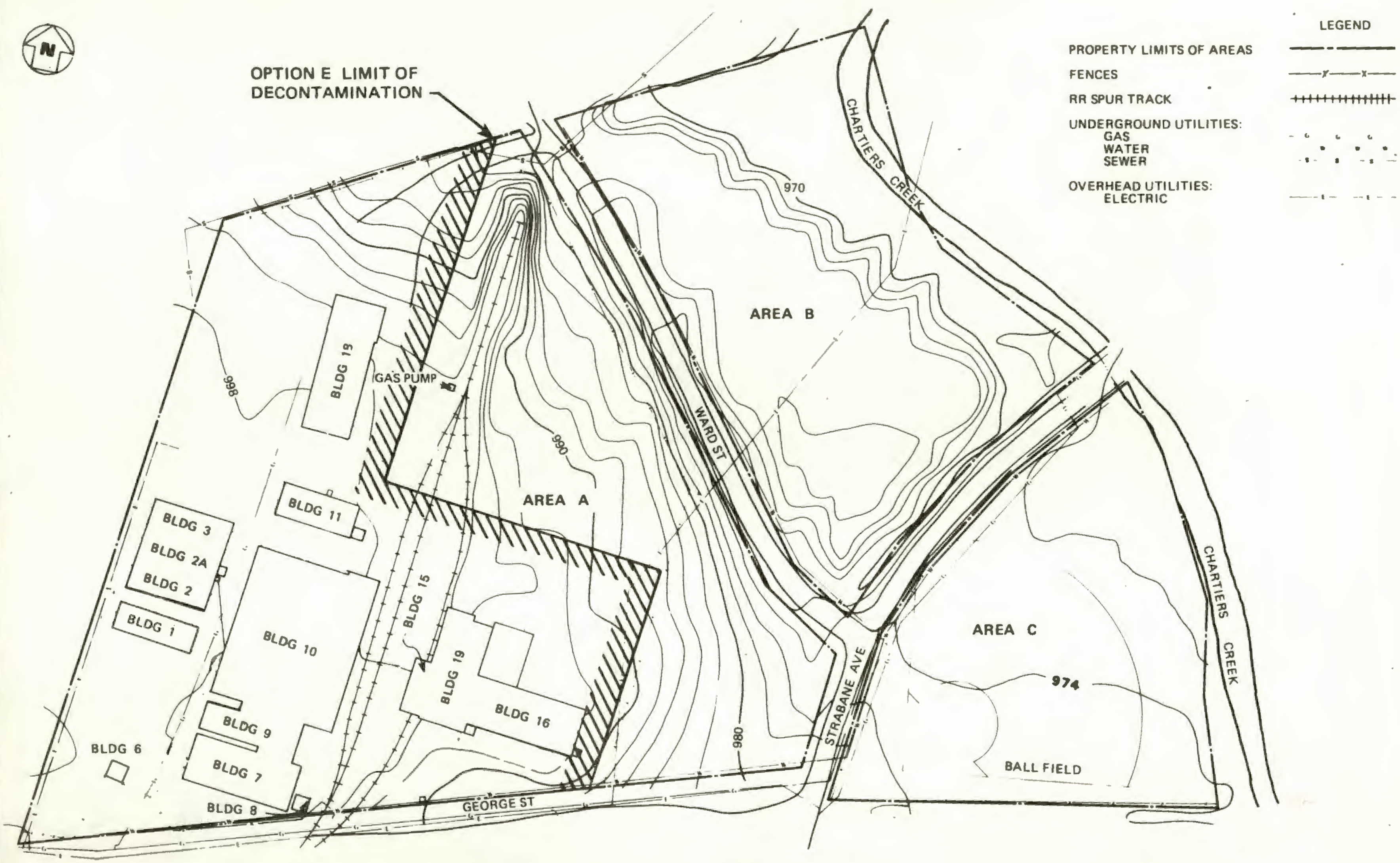


FIGURE 2-3. SITE TOPOGRAPHY

230-006

ORIGINAL (Red)

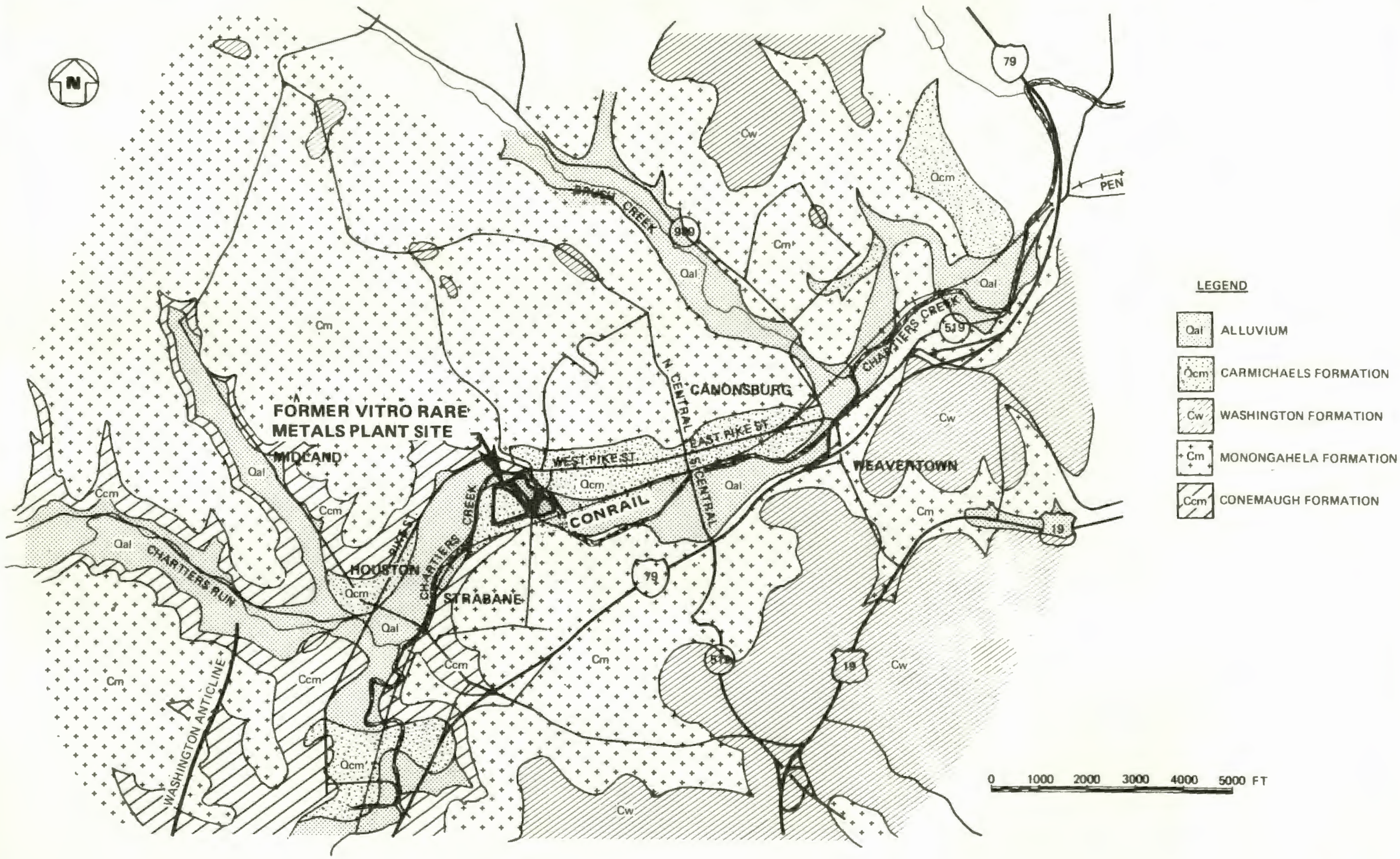


FIGURE 2-4. GEOLOGICAL MAP OF SITE VICINITY

230-006

ORIGINAL (Red)

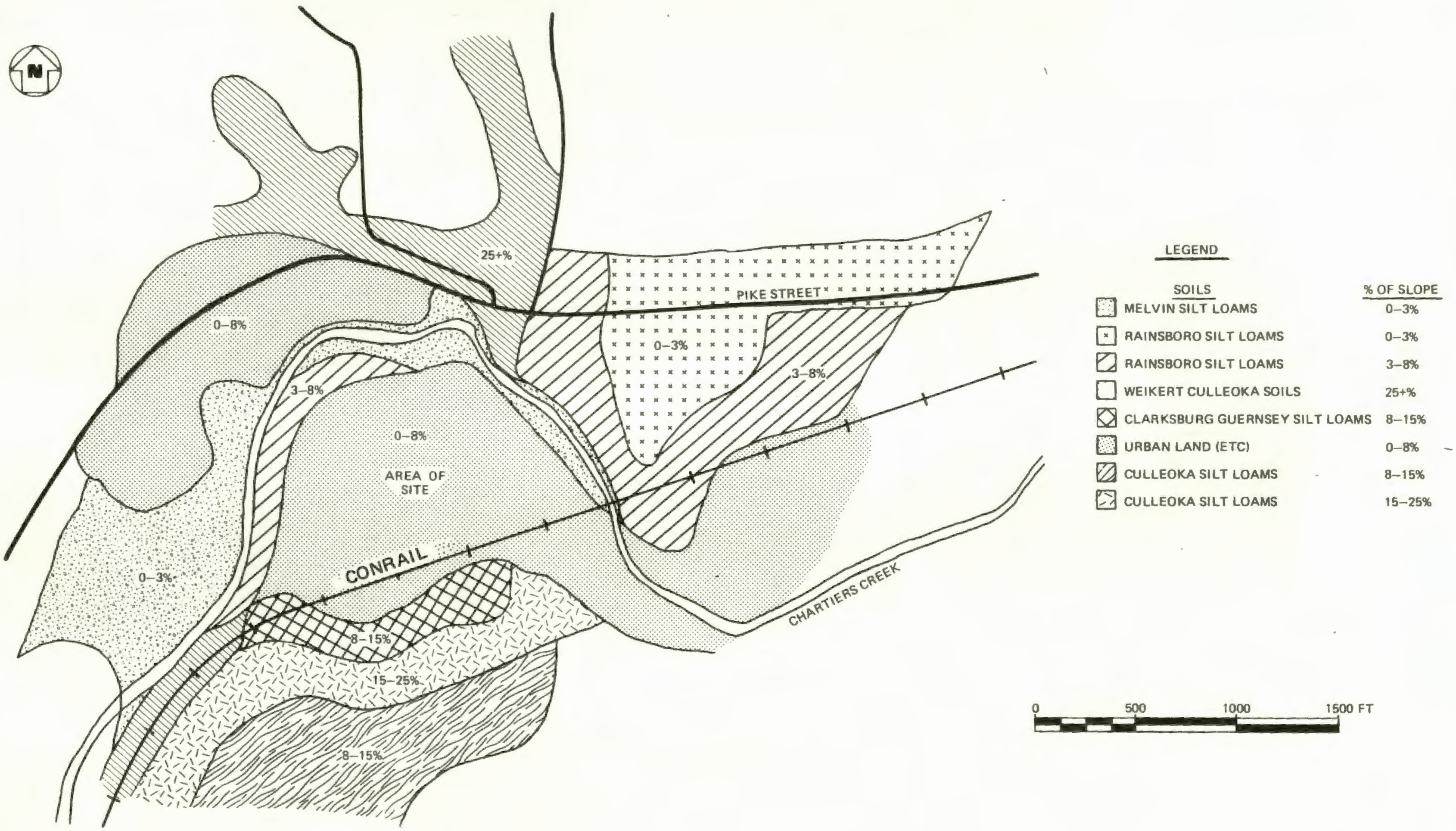


FIGURE 2-5. SOILS IN VICINITY OF SITE

ORIGINAL (Red)

230-006

ORIGINAL
(Red)

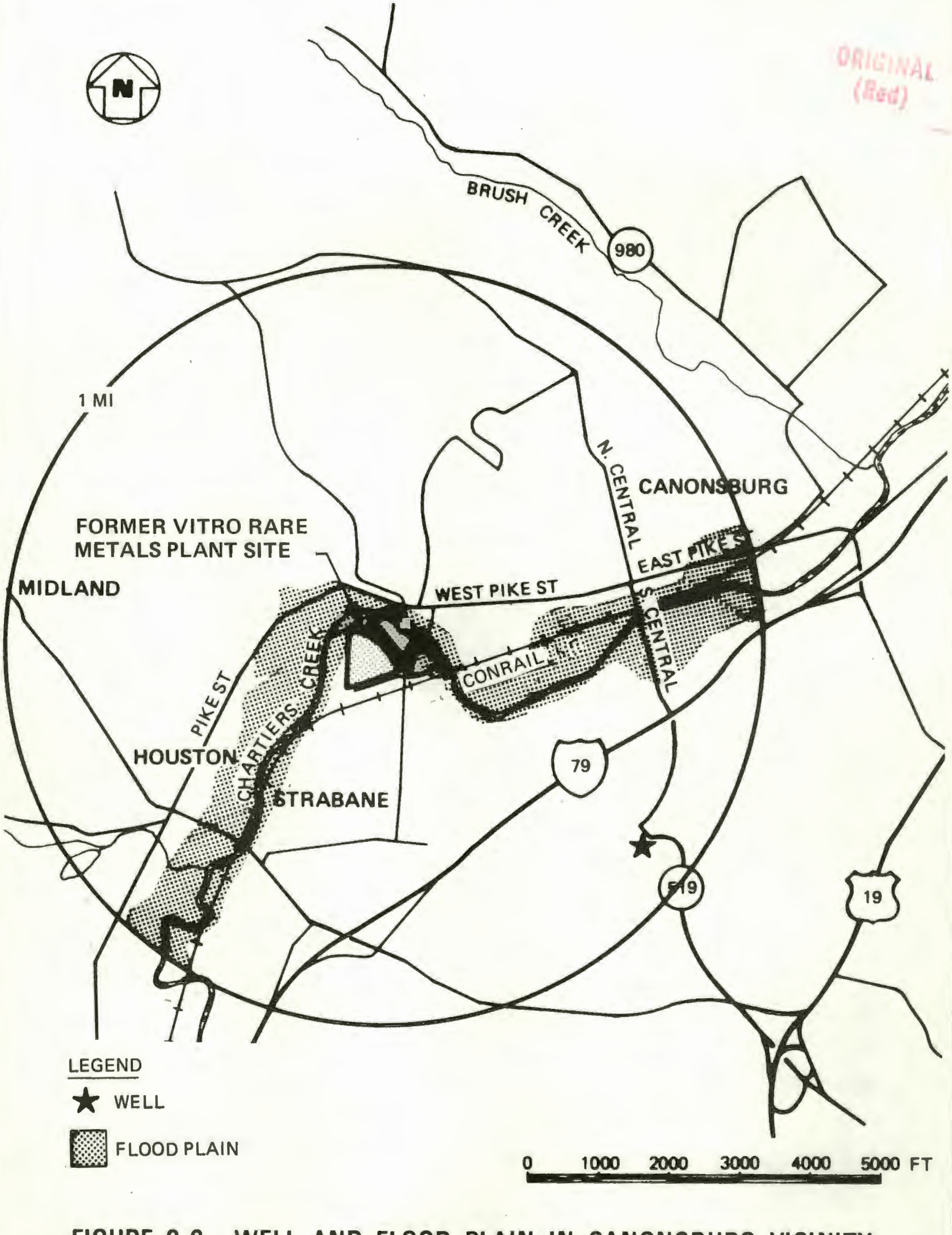


FIGURE 2-6. WELL AND FLOOD PLAIN IN CANONSBURG VICINITY

230-006

ORIGINAL (Red)

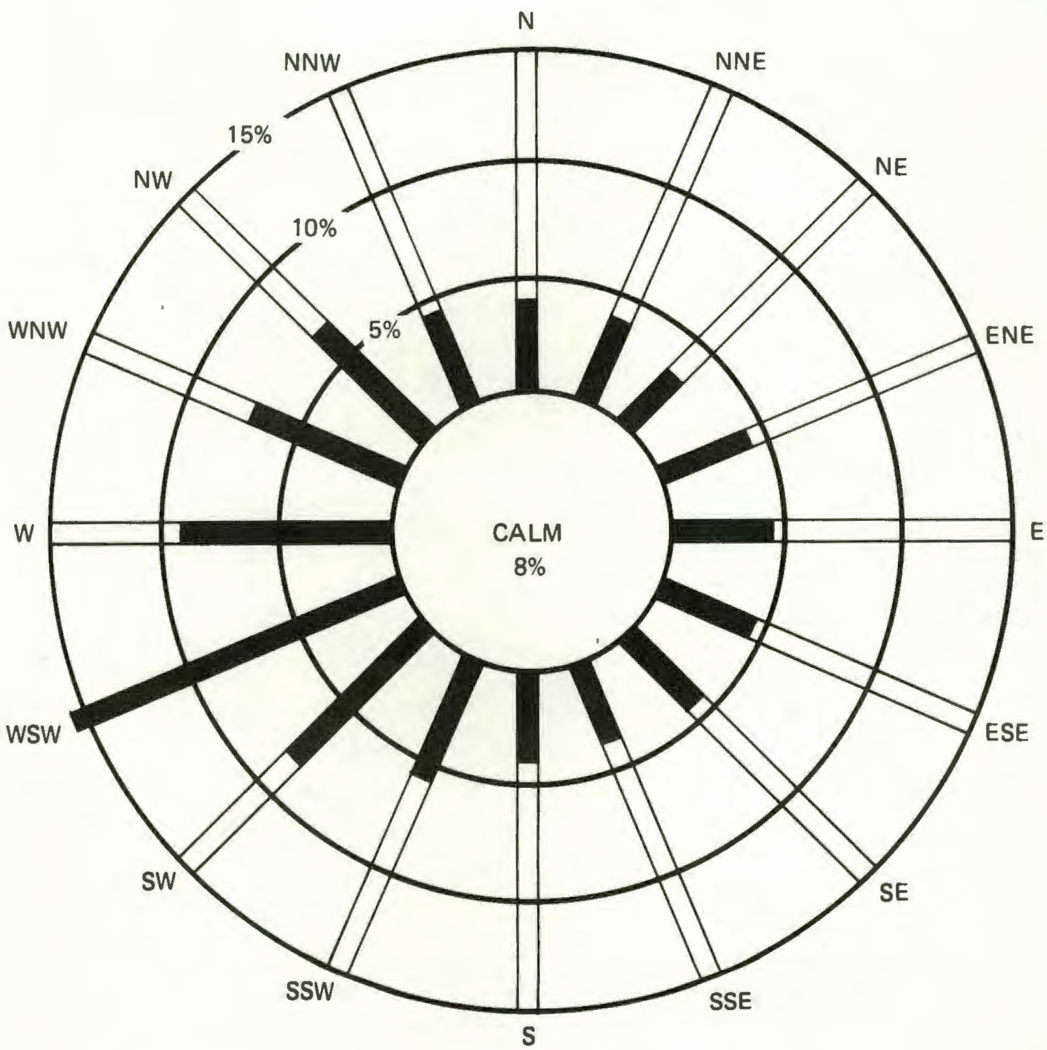


FIGURE 2-7. GREATER PITTSBURGH AIRPORT SURFACE WIND ROSE (CUMULATIVE DATA FROM 1956 THROUGH 1960)

230-006

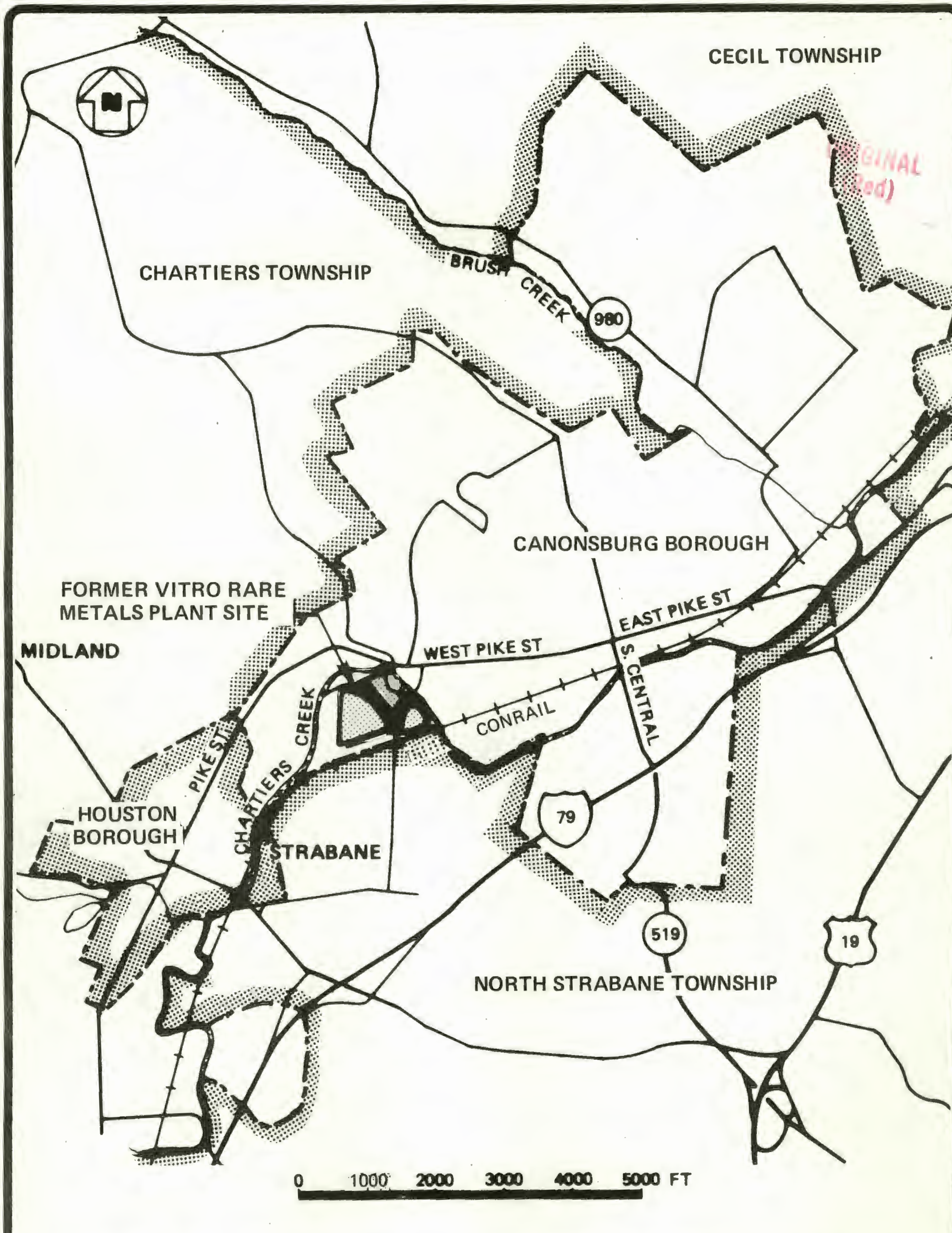
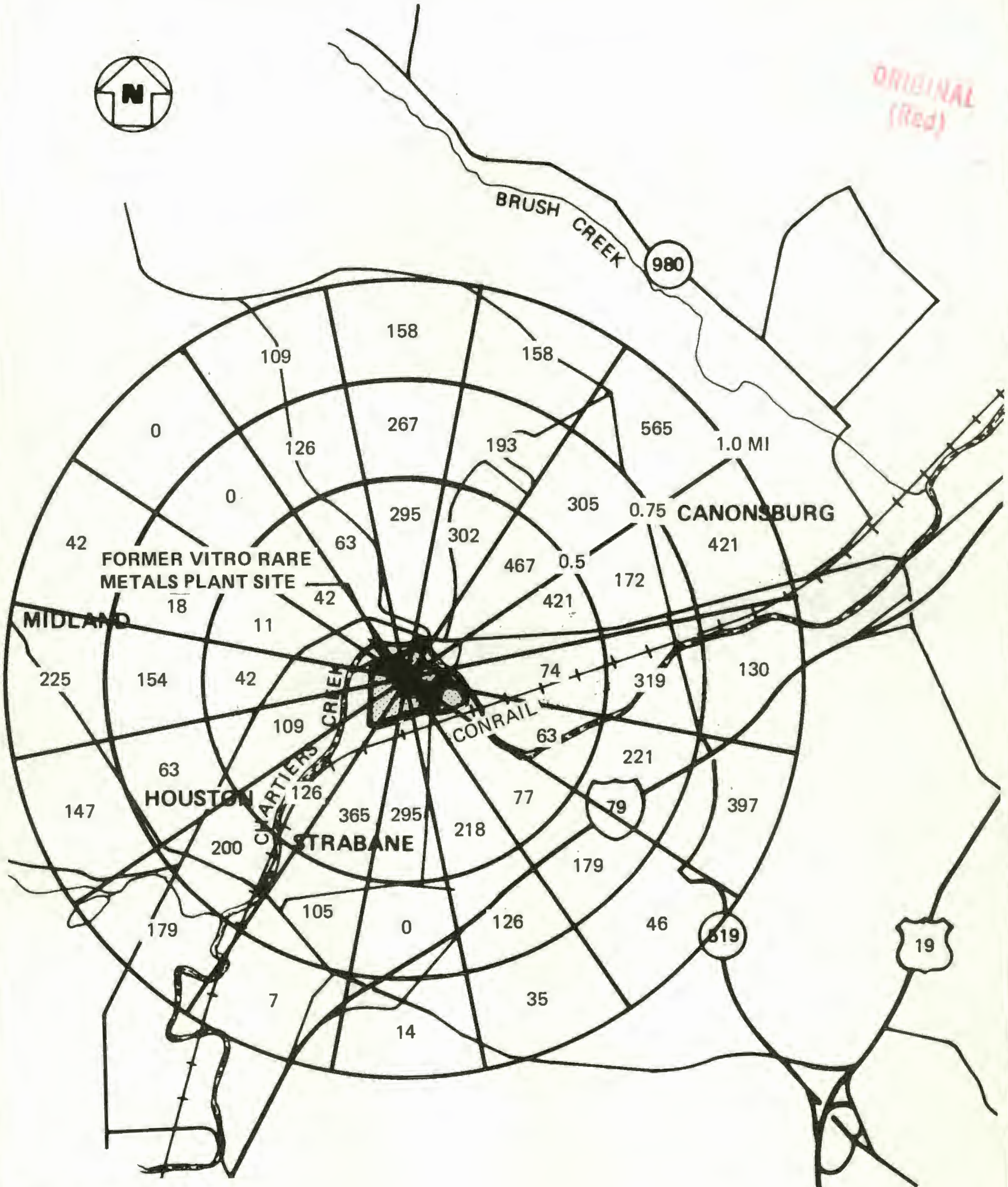


FIGURE 2-8. POLITICAL JURISDICTIONS AND TRANSPORTATION ROUTES

230-006

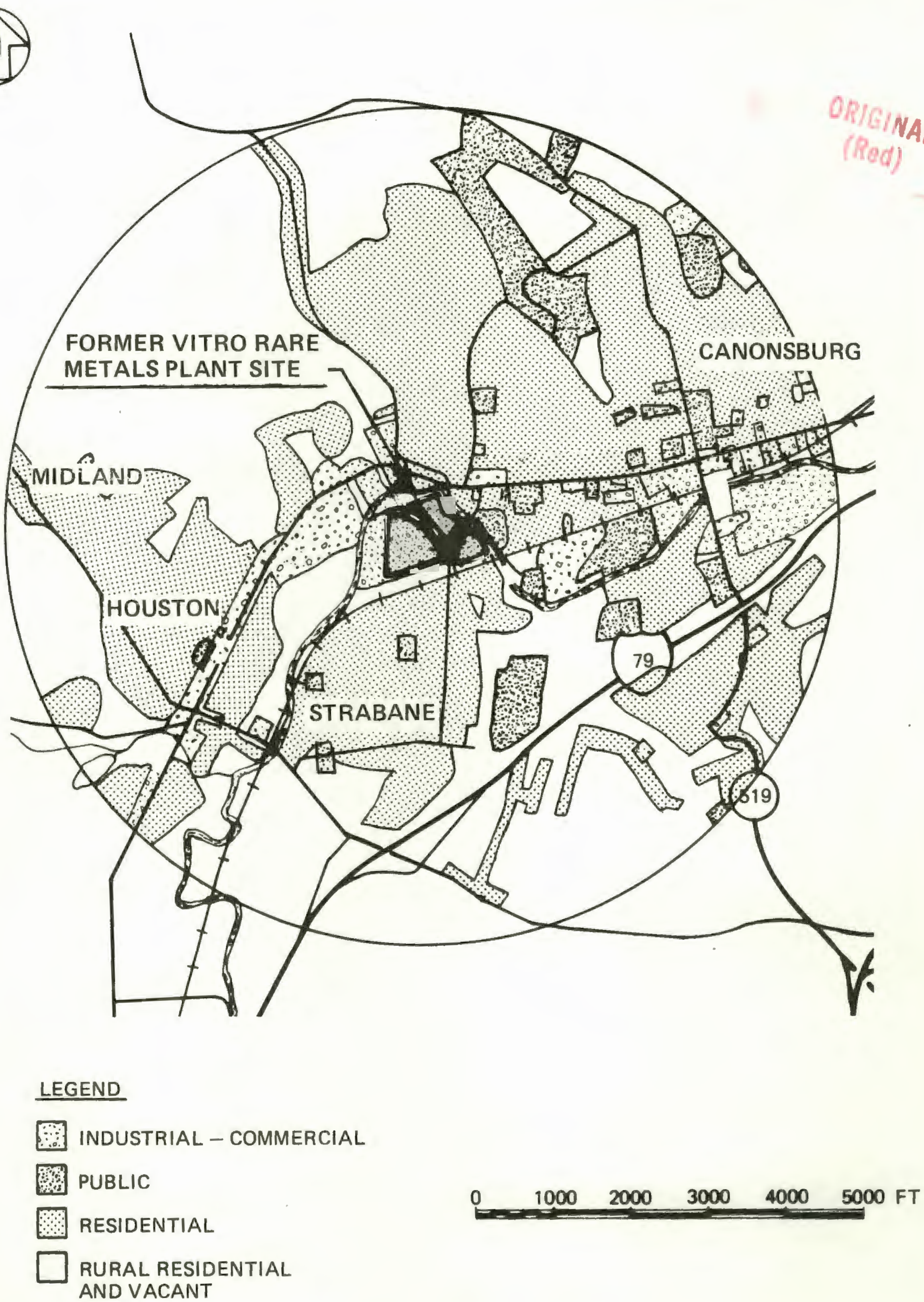


NOTE: NUMBERS REPRESENT
POPULATION ESTIMATES
PER SECTION

0 1000 2000 3000 4000 5000 FT

FIGURE 2-9. POPULATION DISTRIBUTION OF SITE VICINITY

230-006



ORIGINAL (Red)

FIGURE 2-10. LAND USE OF SITE VICINITY

230-006

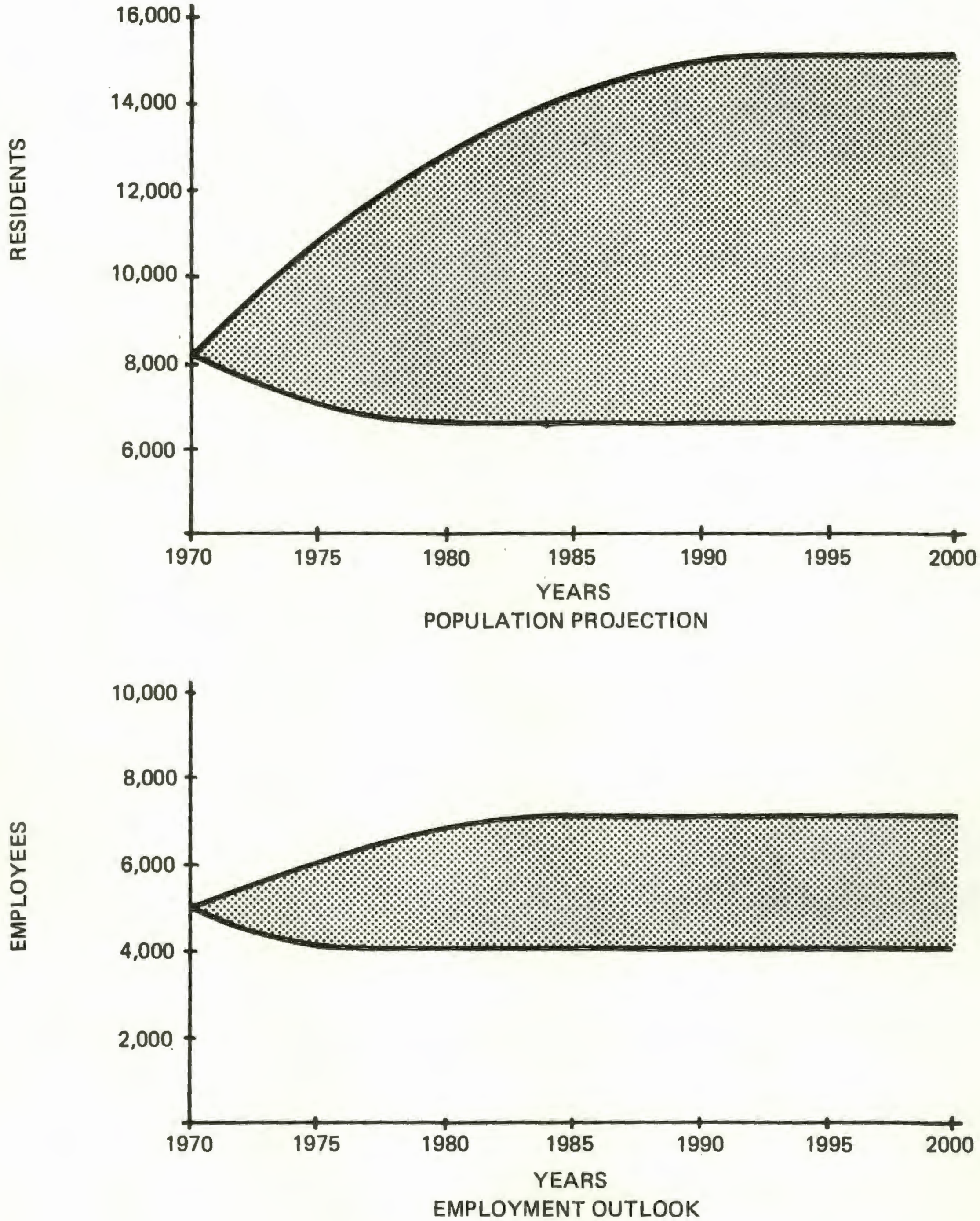
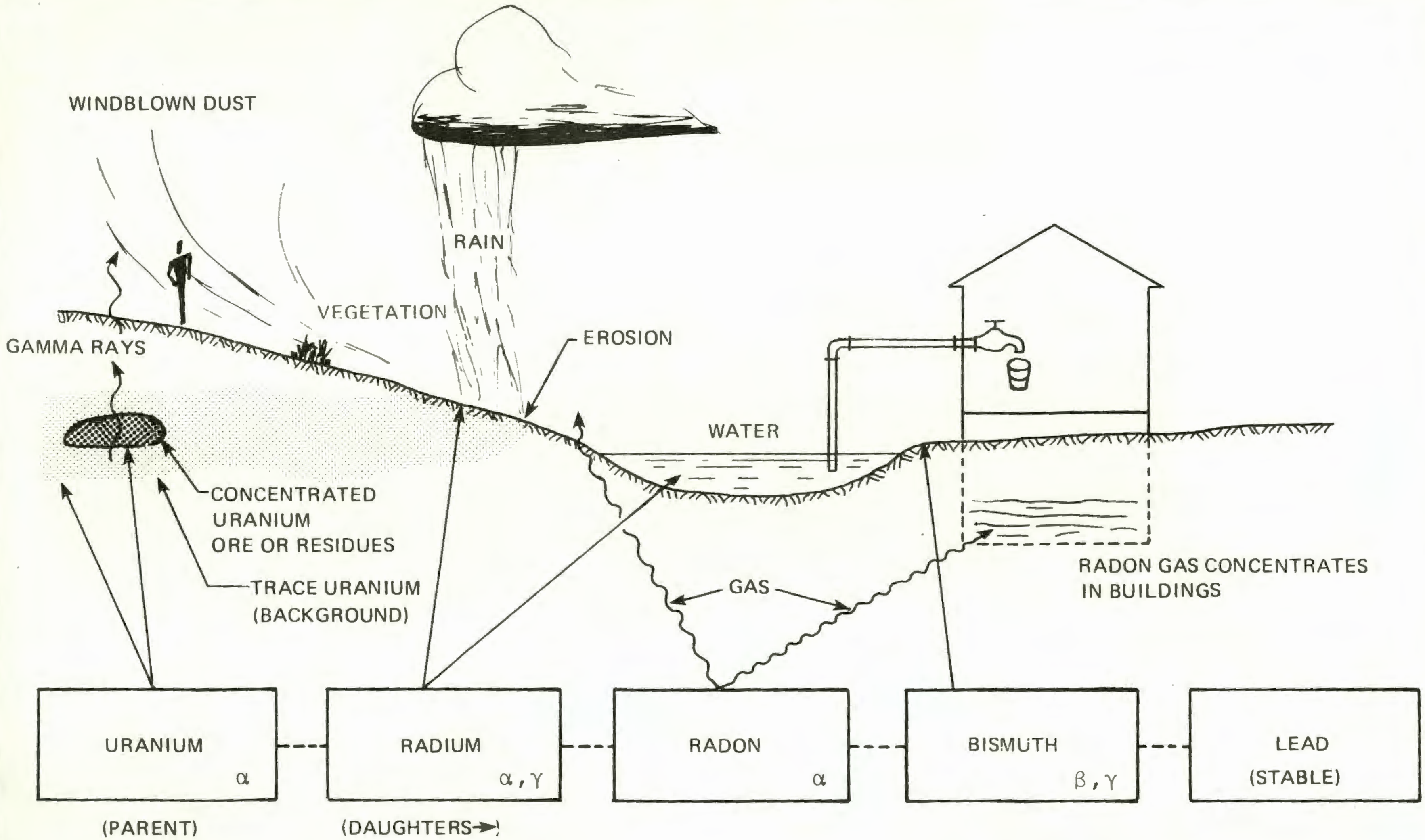


FIGURE 2-11. POPULATION AND EMPLOYMENT OUTLOOK FOR AREA WITHIN 1 MI OF SITE

230-006



NOTE: RADIOACTIVE DECAY CHAIN AS SHOWN IS NOT COMPLETE

FIGURE 2-12. URANIUM-238 RADIOACTIVE DECAY CHAIN (ABBREVIATED) AND MECHANISMS OF TRANSPORTING RADIOACTIVITY FROM URANIUM TO MAN

230-006

TABLE 2-1

SOIL PROPERTIES(20,21)

Soil	Description	Slope (%)	Depth to Seasonally High Water Table (ft)	Bed-rock (ft)	Drainage	Permea-bility	Available Water Capacity	Compaction	Flood Hazard	Frost Potential
Clarksburg	Silt loams formed in relative non-acid colluvial material	8-15	1.5 to 3	4+	mod well	mod slow	mod	fair to good	low	moderate
Culleoka	Silt loams formed from interbedded shale siltstone, sandstone, lime-stone on upland slopes	8-80	>6	1.5 to 3	well	moder-ate	mod	good	low	moderate
Guernsey	Silt loams formed from interbedded clay shale, mudstone, and limestone in upland slopes	8-15	1.5 to 3	4+	mod well	slow	mod	good	low	moderate
Melvin	Silt loam formed from stratified, relatively non-acid alluvium on flood plain	0-3	0-0.5	6+	poorly	mod slow	low	fair	high	high

TABLE 2-1 (Cont)

Soil	Description	Slope (%)	Depth to Seasonally High Water Table (ft)	Bed-rock (ft)	Drainage	Permea-bility	Available Water Capacity	Compaction	Flood Hazard	Frost Potential
Rainsboro	Silt loam formed from stratified, relatively non-acid stream deposits above flood plain	0-8	1.5 to 3	5+	mod well	mod slow	low	fair	high	moderate
Weikert	Silt loam formed from shale, silt-stone, and sandstone on upland slopes	25-80	>6	1-1.5	well	mod rapid	low	good	low	moderate
Urban Land	Too variable - Normal interpre-tations are not made									

Note: See Figure 2-6

TABLE 2-2

SUMMARY OF RADIOLOGICAL MEASUREMENTS PERFORMED BY ORNL(1[illegible]

Parameter	Site Buildings	Plant Site	Remedial Action Guidelines
Radium in Surface Soil (^{226}Ra pCi/g in soil)	---	4-4200	6.2[a]
Radon Concentration (pCi/l)	2-108	0.8-17	
Radon Daughters[b] (WL)	0.01-0.68		0.022[c]
External Gamma (μR/hr)	4-310	20-1600	30[a]
Transferable Surface Alpha Contamination (dpm/100 cm^2)	<20-400	---	20

[a]Background plus guideline levels

[b]Estimated 24-hr average using Ra:RaA:RaB:RaC = 1:0.92:0.67:0.54

[c]Based upon 0.002 WL as natural background value (not measured at Canonsburg)

CHAPTER 2 REFERENCES

1. Formerly Utilized MED/AEC Sites Remedial Action Program, Interim Report; "Radiological Survey of the Former Vitro Rare Metals Plant, Canonsburg, Pennsylvania;" DOE/EV-0005/3; ORNL, Health and Safety Research Division; Oak Ridge, Tennessee; Apr 1978

2. Washington East Quadrangle Pennsylvania-Washington Counties; USGS; 1953; photorevised 1969.

3. Canonsburg Quadrangle Pennsylvania; USGS; 1969; photorevised 1969.

4. "Final Environmental Statement, Chartiers Creek Local Flood Protection Project, Chartiers Creek Basin, Pennsylvania;" U.S. Army Engineer District at Pittsburgh, Pennsylvania; Jan 1975.

5. E.W. Shaw and M.J. Minn; Geologic Atlas of the U.S.; Burgettstown-Carnegie Folio, Pennsylvania; USGS; 1911.

6. Fredrick G. Clapp; Geologic Atlas of the U.S.; Amity Folio; USGS; 1907.

7. Green and Washington Counties, Pennsylvania Soil Interpretations; U.S. Department of Agriculture Soil Conservation Service in Cooperation with the Pennsylvania State University College of Agriculture and the Pennsylvania Department of Environmental Resources; 1974.

8. Thomas G. Newport; "Summary of Ground Water Resources of Washington County, Pennsylvania;" Water Resources Report 38; USGS and the Commonwealth of Pennsylvania Department of Environmental Resources, Bureau of Topographic and Geologic Survey; 1973.

9. Data from the Army Corps of Engineers, Pittsburgh Office; May 1978.

10. Data from the Pennsylvania Department of Environmental Resources, Pittsburgh Office; May 1978.

11. Data from Well Records of the Pennsylvania Department of Environmental Resources; Bureau of Topographic and Geologic Survey; 1976.

12. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data Service; National Climatic Center; Asheville, North Carolina.

13. Borough of Canonsburg Comprehensive Plan with Background Studies; Kendree and Shepherd Planning Consultants, Inc.

ORIGINAL (Reg)

14. Chartiers Township Comprehensive Plan; The Selck Minnerly Group AIA, Architects and Planning Consultants.

15. "Radiation Pathways and Potential Health Impacts from Inactive Uranium Mill Tailings;" GJT-22; Ford, Bacon & Davis Utah Inc., Salt Lake City, Utah; July 1978.

16. Letter to W. E. Mott, DOE, Division of Environmental Control Technology; from H. Hollister, DOE, Division of Operational and Environmental Safety; May 22, 1978.

17. Data from the Environmental Measurements Laboratory; June 8, 1978.

18. Summary of Radon Monitoring by EML at ECT Sites; data presented at DOE meeting at Germantown, Maryland; Mar 22, 1979.

19. Letter to Ford, Bacon & Davis Utah Inc.; from W. E. Mott, DOE, Division of Environmental Control Technology; Aug 24, 1978.

20. Soil Survey Interpretations for Greene and Washington Counties, Pennsylvania; Vol 1; U.S. Department of Agriculture; 1974.

21. Data from J. Paxton; Washington County Conservation District.

ORIGINAL (Red)

ORIGINAL
(Red)

CHAPTER 3

ENVIRONMENTAL IMPACTS OF THE PROPOSED REMEDIAL ACTIONS

ORIGINAL (Red)

CHAPTER 3

ENVIRONMENTAL IMPACTS OF THE PROPOSED REMEDIAL ACTIONS

This chapter describes the environmental impacts associated with the proposed options for remedial action which are discussed in the companion Engineering Evaluation Report(1) and summarized in Table 1-1 of Chapter 1.

The options for remedial action, except for Option A, are formulated to limit or to reduce exposure from radioactive contaminated materials with minimum impact on the environment and without undue risk to health or safety. The impacts associated with each option are presented to reflect these considerations, and the means for minimizing or controlling the various impacts are offered.

3.1 IMPACTS OF PROPOSED OPTIONS FOR REMEDIAL ACTION

The environmental impacts associated with each of the six proposed options for remedial action (A-F) for the Canonsburg site are discussed with respect to physical, biological, and socioeconomic impacts. Discussion of the impacts of each option is supplemented by tables that summarize the associated impacts. The impacts are identified as short-term adverse (STA), short-term beneficial (STB), long-term adverse (LTA), long-term beneficial (LTB), not applicable to the specific action (NA), and negligible impact (*).

The effects generally are presented to show the prolonged impacts attributable to the remedial action. In several options it is necessary to present the impacts that would occur during implementation of the remedial action, and the ultimate impacts that would result after completion of the particular remedial action.

The impacts as discussed for Option A apply and are in force until a remedial action changes one or several of the impacts. In the presentation of impacts of remedial actions for Options B through F, two conventions are used to facilitate the presentation and to limit repetition:

(1) Those impacts that do not differ from those discussed in Option A, during or after a remedial action, are listed in appropriate tables, and may be mentioned in the text. The impacts are listed as short term during implementation of a remedial action and as long term after completion of the action. Generally these impacts are not emphasized as much as those impacts that are different from Option A.

(2) Those impacts that change during or after completion of a remedial action are listed in the tables and

discussed in more detail in the text. Again, during implementation the impacts are referred to generally as short term and after completion as long term.

3.1.1 Option A - No Action

Option A (no remedial action) is presented so that the impacts of the existing conditions can be compared with the various impacts of the remaining proposed options for remedial action. If no action were taken, the radiation environment of the existing conditions would remain unchanged and the impacts and risks would continue indefinitely. A summary of the potential impacts is shown in Table 3-1.

a) Mineral Resource and Soil Impacts

The soil at the site and at several off-site locations is contaminated with levels of radioactivity that exceed the current guidelines.[2] This contamination is considered to be an LTA impact upon these soils.

b) Ambient Radiation Impacts

On site, radon concentrations and gamma radiation have been measured that are many times the natural background levels. Radon daughter working levels in buildings in the Canonsburg Industrial Park exceed proposed DOE criteria for remedial action. Radon concentrations in air about 400 ft from the site boundaries are less than twice the natural background radon concentration in the vicinity of Canonsburg. Gamma radiation levels adjacent to the site generally are 2 to 3 times natural background levels, with higher radiation in a vacant area to the south of the site. The present radiological conditions at the site constitute an LTA impact relative to the ambient radiation levels.

c) Ground and Surface Water Impacts

All water samples from Chartiers Creek had ^{226}Ra concentrations well within EPA Drinking Water Regulations and are within the ^{226}Ra natural background range.[2] Several water samples collected from drill holes on the site exhibited ^{226}Ra concentrations above the EPA Drinking Water Regulations and the radionuclide concentration guidelines in 10 CFR 20. These elevated concentrations have the potential for contaminating off-site ground and surface waters. Ground water is not tapped near the site and surface water samples did not exhibit contamination. However, there is a potential LTA impact on ground and surface waters as long as the contaminated materials remain.

d) Erosion Impacts

The presence of exposed contaminated materials on the site is an LTA impact with respect to spread of contamination by erosion. Sediment samples from on-site drainage ditches indicate that such erosion has occurred and would be expected to continue. If the site were to be inundated to a significant extent, there would be some erosion of contaminated soils in the absence of adequate soil stabilization measures (such as vegetative cover implacement).

e) Air Quality Impacts

Radon concentration measurements off site are above natural background concentrations;(2) consequently there is an LTA impact on air quality. Daily truck traffic on the unpaved portions of the site generates dust and impacts adversely on the air quality. Air particulate measurements are not available. Severe wind storms are likely to increase radioactive air particulate concentrations temporarily. As long as exposed contaminated areas remain, this potential LTA impact exists.

f) Biological Impacts

No impacts have been found that can be shown to affect flora or fauna on the site as a result of elevated radiation levels. No survey of endangered or rare species of plants or wildlife has been undertaken at the site. Because the entire site has been disturbed by construction and deposition of tailings, with the possible exception of the lower portion of Area A, plant and wildlife species on the present site have been re-established over the past two decades since processing operations ceased. A negligible impact on flora and fauna is therefore shown in Table 3-1.

g) Land Use Impacts

Real estate brokers in the area indicate that Area A is ideal for light industry (its present use) and for further development because it is convenient to railway and freeway access and to nearby residential areas. Areas B and C are more suited for greenbelt or community recreation areas because of the unstable soil conditions and potential flood danger. Area C is a former ballpark that was closed after recognition of the presence of contamination. Railroads on the north and south, Chartiers Creek on the east, and a factory on the west separate the site from residential areas. The presence of contaminated material on the site is an LTA impact with respect to site use, but it has not affected the land use of surrounding property.

h) Health Impacts

Based upon four off-site measurements of radon around the site,(3) an estimate was made of the health impact to the population from inhalation of radon daughters. About 1,000 ft to the northeast, the radon concentration was 0.5 pCi/l above the measured background concentration in the area.

In three other directions, the radon concentration was only 0.2 pCi/l above natural background levels 400 ft from the site. Assuming these values remain constant to 0.5 mi from the site (a conservative assumption), the maximum individual risk, as shown by calculations in Appendix B, is 2 x 10^{-5} health effects per year, or a population risk of about 0.03 health effects per year. The individual lung cancer risk in Pennsylvania is 4.7 x 10^{-4} health effects per year,(4) about 25 times greater than the risk due to radon from the site.

Along Latimer Avenue, south of the site, the measured gamma radiation levels are about twice the natural background value of 11 R/hr. This leads to an annual dose of 100 mrem and an individual cancer risk of 1 x 10^{-5} health effects per year. During a 1-yr period, residents also would receive about 100 mrem from natural background radiation.

Employees who work in the Canonsburg Industrial Park receive exposure principally from gamma radiation and from inhalation of radon daughters. Radiation measurements were made in each of the buildings(2,3) and exposure and risk were calculated from these data and from occupancy factors for commercial firms at the site.

Table 3-2 lists the estimated lung cancer rates from exposure to radon daughters for the occupants of each of the buildings now in use. The total risk for all 110 employees is 3 x 10^{-2} potential cancer cases per year. Using lung cancer statistics for Pennsylvania, the cancer risk for 110 people would be 5.2 x 10^{-2} health effects per year,(4) or about double the risk to employees from radon daughter inhalation at the site.

In Table 3-3, the estimated cancer rates due to external gamma exposure in the buildings are listed. The total cancer risk for all occupants of the site is 3 x 10^{-3} potential cancer cases per year. The potential cancer risk from external gamma radiation is about one-tenth the potential lung cancer risk from inhalation of radon daughters.

The health effects are considered to be LTA impacts, based on the information given above. Descriptions of these health effects calculations and additional calculations associated with the remaining options are included in Appendix B.

i) Employment Impacts

Some adverse impacts are present relative to employment at the site as a result of the radioactive contamination. There will continue to be a potential LTA impact on employment in the Canonsburg Industrial Park if the radiation levels are not reduced. No large increase in employment at the site would be expected if the contaminated material were removed because only Area A is suitable for development. Areas B and C are less desirable for commercial or industrial facilities because of the potential for flooding; consequently there is little adverse impact on employment in those areas due to the presence of contaminated materials.

ORIGINAL (Red)

j) Land Value Impacts

The radioactive contamination on the site has an LTA impact upon its land value. Real estate brokers in the vicinity estimate that the 11 acres of Area A could be worth approximately $28,000 to $32,000/acre, if the radioactive contamination were not present and if the buildings were removed from the site. The value of Area A then would be approximately $330,000. Because of the contamination within the buildings, their current market value is difficult to determine. The buildings and site have a generally rundown physical appearance and show some lack of preventative maintenance. The current worth of the buildings in their existing conditions (not considering radioactive contamination) is estimated at approximately $1,300,000. Replacement cost of the area and volume of the existing buildings is estimated to be $2,500,000.

Areas B and C, with a total of about 7.6 acres, are of much less value because of the unstable soil conditions and the potential flood danger. Their use for structures would be marginal and highly unlikely, even if the contamination were removed. Their use appears to be best suited for greenbelt or community recreational areas. In a contamination-free condition, their total value would be about $10,000/acre, or a total of $76,000.

Therefore, total estimated current market value of the entire site including structures, assuming no contamination problems, would be $1,706,000 ($330,000 for land area, plus $1,300,000 for buildings, plus $76,000 for land of Areas B and C). This does not include the value of the equipment and furnishings within the buildings. The contamination on the site has had no effect on real estate values surrounding the site. The Borough of Canonsburg has imposed no building restrictions on surrounding properties.

k) Aesthetic Impacts

The presence of contaminated material has negligible impact upon the aesthetic appearance of the site.

There are no impacts from present conditions on cost, noise, safety, or transportation because no actions are involved in this option. These factors are listed in Table 3-1 and are listed as not applicable to Option A.

3.1.2 Option B - Minimal Action

Option B involves only fencing of the three areas of the site to prevent access to contaminated areas, and installation of ground water monitor wells. This option would require the property to be (a) purchased by a government agency and held in perpetuity, (b) controlled by fencing and posted with radiation warning signs, (c) maintained, and (d) radiologically surveyed periodically for land and water pollution.

The impacts associated with Option B would be the same as those for Option A with respect to soil, ambient radiation, ground and surface water, erosion, air quality, and flora and fauna. The STA impacts occur during implementation and the LTA impacts upon completion as shown in Table 3-4. Impacts that are different from Option A are discussed below.

a) Land Use

Fencing the site to deny access would prevent use of the site or the buildings for any purpose, and would be an LTA impact. Businesses would have to be relocated. In addition, there would be the loss of the tax base if the land could not be made available for commercial or industrial uses.

b) Cost Impacts

Compared with the other remedial actions, the cost of this option would be minor, but considered to be an adverse impact because of the requirement for public expenditures. If a fund were established initially to provide interest to cover the cost of periodic surveillance and monitoring of the area and of the water quality for an indefinite period, then the cost of this option would have only an STA impact.

c) Health Impacts

Workers installing the fences would receive an estimated exposure of 50 mrem or less, which could yield a cancer risk of 5×10^{-6} health effects per year. The radon and radon daughter inhalation health risk to the individual worker is estimated to be 1×10^{-5} health effects per year. (See Appendix B for the values used to arrive at these estimates.) This impact is considered to be an STA impact during implementation.

Potential health effects from on-site exposure, discussed in Paragraph 3.1.1, would be eliminated by fencing of the site to prevent access. This option would provide an LTB impact on health based upon elimination of exposure to employees in the industrial park compared with Option A. Off-site exposures from gamma radiation and radon above natural background would not be decreased.

d) Safety Impacts

During construction work, there is always the potential for accidents and thus injury to workers. Based on the 1977 Bureau of Labor statistics[5] given in Option E, it is estimated that 0.4 occupational injuries may occur and the potential is considered to be an STA impact during implementation.

e) Employment Impacts

It is expected that businesses presently located in the industrial park would be relocated and that most employees would retain their jobs; thus, there would be a minor STA impact on present employees at the site. Additional jobs would be available for conducting the remedial actions, resulting in an STB impact. Overall, there would be negligible impact on employment during the remedial actions. If the site were not usable for any purpose, there would be an LTA impact on employment, since the area could not be developed.

f) Land Value Impacts

If the land were acquired and held in perpetuity by a government agency, land value would not be applicable since it could not be sold or developed.

g) Aesthetic Impacts

The installation of a chainlink fence with radiation warning signs around each of the three site areas would have an LTA impact on aesthetics.

3.1.3 Option C - Stabilization of All Areas without Removal of Buildings in Area A

Under Option C, all buildings and structures in Area A would remain in place, and the portion of Area A containing the buildings would be fenced. Areas A, B and C would be stabilized with low-permeability soils to reduce the radon emanation, gamma radiation, and erosion occurring at these locations.

The actions associated with Option C during stabilization are discussed in the Engineering Evaluation Report[2] and are summarized in Table 1-1, Chapter 1. The potential impacts during and after the remedial actions are summarized in Table 3-5.

a) Mineral Resource and Soil Impacts

Approximately 59,000 yd^3 of clean soil would be required for stabilization of the areas of radioactive contamination. It would be desirable to obtain this soil from various excavation projects in the site vicinity in an effort to conserve soils and minimize or nullify impacts expected at the source of soil removal. If borrow pits are used, they will be restored. Soils on the site would remain in a contaminated condition; therefore, the impact on soils is considered to be long-term adverse.

b) Ambient Radiation Impacts

During remedial actions both radon concentrations and external gamma radiation are an STA impact. By using proper soil placement procedures during stabilization, vehicles need not travel on the exposed contaminated area, thus eliminating the spread of contamination. After placement of the soil, the cover material would be seeded with grasses. Two feet of clean soil would reduce gamma radiation from contaminated areas to natural background levels and would reduce radon flux by a minimum of 25%. These reductions would allow access to Areas B and C, and the unfenced part of Area A, although restrictions on their use would be necessary. No construction or excavation would be allowed.

The LTB inpact derived from reduction of radiation through stabilization on site would apply to individuals who might use areas of the site for recreational purposes and to residents and workers near the site where gamma radiation or radon levels are now above natural background levels.

c) Ground and Surface Water Impacts

There is a potential of increased erosion of cover material by surface runoff during implementation of Option C. However, the cover material is not contaminated and the impact is considered to be negligible. Placement of cover material on the exposed areas followed by revegetation would reduce the potential for erosion of contaminated material and the possibility of contaminated materials reaching Chartiers Creek from surface runoff. The presence of the contaminated material would continue to have a potential LTA impact for contaminating the ground water. Installation of ground water monitoring wells around the site would aid in detecting any ground water contamination.

d) Erosion Impacts

As indicated above, stabilization would reduce the potential for erosion of the exposed contaminated area by surface runoff. Stabilization also would eliminate the potential for wind erosion of contaminated material. Therefore, an LTB impact on erosion would result from stabilization compared with present conditions. No additional contaminated material would be exposed during the stabilization operations; therefore, there would be no increased potential for erosion during implementation of Option C.

e) Air Quality Impacts

Minor STA impacts on air quality would be expected primarily from equipment exhaust fumes during the time required to complete Option C. Increased dust from placement of the clean soil would be negligible, since dust control procedures would be employed. Reduction of radon emanation would be an LTB impact on air quality.

ORIGINAL (Red)

f) Biological Impacts

Vegetation removal from the portion of the site to be stabilized would be a minor STA impact. The amount of vegetation to be removed during site clearance prior to stabilization cover implacement would have a negligible impact on local solid waste disposal facilities. Revegetation of the stabilized area with grasses would occur as a part of site restoration procedures.

Some small faunal species may be displaced during stabilization, but this would be only an STA impact until revegetation was completed and habitats reestablished. An LTB impact would result after the entire area was stabilized and vegetation was reestablished.

g) Land Use Impacts

Prior to stabilization of the Canonsburg site businesses would have to be relocated, and public access to the site would be restriced during stabilization operations. This is considered to be an STA impact.

An LTA impact on land use of the fenced portion of Area A where the buildings are located would result since access would be prevented. Compared with present conditions, stabilization of Areas B and C would be an LTB impact since those areas then could be used but would have restrictions on their use so that no excavation or construction of buildings could take place.

h) Cost Impacts

The expenditure of public funds, including provision for a perpetual care fund for monitoring and maintenance, would be an STA impact. There would be no cost impacts once the actions were completed.

i) Noise Impacts

During implementation of Option C, increased noise would be an unavoidable STA impact both on site and off site. The noise would be caused by trucks bringing cover material to the site and by equipment spreading and compacting the cover material. All operations would be conducted during daylight hours and the major part of the work would be accomplished in less than 2 mo. There would be no noise impacts upon completion of the actions.

j) Health Impacts

The estimated worker exposure to radon daughter concentration would yield a cancer risk of 2 x 10^{-5} health effects per year. Workers that perform the remedial action would receive an estimated exposure of 100 mrem or less from external gamma radiation, which is approximately equal to the natural gamma radiation exposure received annually. The estimated worker exposure would yield a cancer risk of 1 x 10^{-5} health effects per year. During implementation, the same worker would receive a background exposure from natural gamma radiation of 22 mrem. Upon completion of Option C, present health impacts on on-site employees would be reduced although the buildings could not be occupied. Off site there would be negligible health impacts from the site after completion of the option. Thus, there would be an LTB impact on health compared with Option A.

k) Safety Impacts

There is the possibility of occupational injuries occurring during earthmoving work, and the potential for traffic accidents increases with increased traffic. This option involves transport of approximately 4,200 14-yd^3 truckloads of clean dirt for stabilization within a 60-working-day period. Comparison with accident statistics discussed under Option E indicates that 1 injury may occur due to construction-type work and 0.1 accidents and 0.01 fatalities are potentially possible for a 25-mi haul distance; consequently, STA impacts would result. There would be no safety impacts when Option C is completed.

l) Transportation Network Impacts

Considering that 4,200 truckloads of cover material and vegetation are involved in implementing this remedial action, there would be an STA impact on traffic off site due to possible congestion. The impact is not applicable when remedial actions are complete.

m) Employment Impacts

During the remedial action operations there would be negligible overall impact on employment. Some employees may lose their jobs as a result of business relocations, but additional jobs would become available for conducting the remedial actions. This situation would then result in both STA and STB impacts. An LTA impact would result because the site could not be developed after remedial actions were completed.

n) Land Value Impacts

The required ownership by a governmental agency and the restricted use of the site would make land value meaningless and therefore not applicable.

o) Aesthetic Impacts

Aesthetics on site would be adversely affected for the short-term during the stabilization procedures (STA impact). Following completion of the remedial action, the overall appearance of Areas B and C would improve and an LTB impact would result. Buildings in Area A would remain and deteriorate, leading to an LTA impact.

3.1.4 Option D - Stabilization of All Areas with Removal of Buildings in Area A

This option is similar to Option C except that buildings in the developed part of Area A would be demolished and buried in the undeveloped part of Area A prior to stabilization of all three areas. No fencing would be required. A summary of the impacts is shown in Table 3-6. Impacts of Option D are the same as those of Option C except as discussed in the paragraphs that follow.

a) Mineral Resource and Soil Impacts

About 7,000 yd^3 of additional soil would be needed for covering building rubble and for stabilizing the areas occupied by the buildings.

b) Land Use Impacts

All three areas would be similarly stabilized and could have limited use, such as for recreation. Restrictions would be necessary so that no excavation or construction of buildings would be allowed on the site. This would be an LTA impact for Area A, since this area would be suitable for industrial or commerical development if contamination were not present. Stabilization of Areas B and C would result in LTB impacts on land use compared with present conditions.

c) Cost Impacts

This option would be slightly more costly than Option C, but more area would be available for limited use. Cost would be an STA impact if a perpetual care fund were included in the original cost.

d) Noise Impacts

Option D would lead to greater noise impact than Option C during razing of the buildings; however, noise would still be an STA impact.

e) Health Impacts

The greater time for implementation of Option D would result in slightly higher radon daughter inhalation and external gamma exposure, approximately 4 x 10^{-5} health effects per year and 2 x 10^{-5} health effects per year (150 mrem), respectively, to workers conducting the remedial action. During implementation, workers would receive an exposure of 33 mrem from natural background gamma radiation. The LTB impact on health with the completion of Option D is basically the same as for Option C.

f) Safety Impacts

The estimated number of occupational injuries for Option D would increase to 2 over previous options. This potential impact is considered to be an STA impact. Transportation accidents and fatalaties are estimated to be the same as for Option C.

g) Aesthetic Impacts

Following completion of Option D, there would be an LTB impact on aesthetics since the entire site would be stabilized and revegetated.

3.1.5 Option E - Decontamination and Restoration of Part of Area A; Stabilization of Area B and Remainder of Area A; Decontamination and Restoration of Area C

This option makes portions of the site available for unrestricted use and removes the most likely source of ground and surface water contamination. A summary of the impacts of Option E is shown in Table 3-7.

a) Mineral Resources and Soil Impacts

About 104,000 yd^3 of clean soil would be required for stabilization and backfill of excavated areas to comply with Criterion B. There would be little change in the LTA impact with respect to soil contamination in Areas A and B. Decontamination of Area C would be an LTB impact on the soil in that area.

b) Ambient Radiation Impacts

There is expected to be an STA impact on site and negligible impacts are expected off site during implementation of the option as contaminated material is excavated and buildings are razed. Adding moisture to the soil as necessary during excavation would aid in limiting increases in radon emanation.

There would be LTB impacts in all three areas upon completion of this option. Contaminated materials would be removed from the developed part of Area A and from Area C. Stabilization of the remainder of Areas A and B would reduce gamma radiation to natural background levels and reduce radon emanation by 25 to 90%, depending upon the type of soil and compaction achieved during stabilization.

c) Ground and Surface Water Impacts

Removal of contaminated materials from Area C would be an LTB impact with respect to potential ground and surface water contamination. There would be only a minor change in the LTA impact due to the contaminated materials remaining in Areas A and B.

d) Erosion Impacts

Potential for erosion of contaminated material into Chartiers Creek would be reduced in all three areas as a result of this option. Measures would be taken, such as temporary diking, to prevent spread of contamination by erosion during implementation of this option; therefore, any short-term impact would be negligible. These remedial actions therefore provide an LTB impact.

e) Air Quality Impacts

During excavation and stabilization operations some increase in air particulates would be expected; however, dust control procedures would be employed to minimize this STA impact. Adding moisture to the soil as required also would limit short-term increases in radon emanations during excavation of contaminated materials. After completion of Option E, there would be an LTB impact on air quality compared with present conditions.

f) Biological Impacts

Removal of vegetation and soil from the site would have an STA impact on plants and small wildlife. Vegetation cleared from the site could be buried at the site, resulting in no impact on solid waste disposal facilities. With restoration and revegetation, the present species should reestablish themselves as they have in the past on the disturbed areas of the site. If redevelopment of Area A were to occur following restoration, negligible change would result in plant and wildlife habitat compared with present conditions.

g) Land Use Impacts

Although the Canonsburg Industrial Park is in operation in a part of Area A, it cannot continue to operate indefinitely without remedial action. However, removing the contaminated buildings and soil from the industrial park area would make it available for redevelopment on a long-term basis. Therefore, an LTB impact would result from implementation of Option E.

Much of the building rubble would be placed between Areas A and B. This possibly would require the rerouting of Ward Street. Relocation of Ward Street adjacent to the present industrial park area could improve the value of that area for commercial development. The stabilized portion of Area A and Area B could be used for parking as long as restrictions were placed on excavation and building. These potential uses would be an LTB impact on land use for Area B compared with the present conditions. Area B cannot be used now because of the presence of contaminated material and elevated gamma radiation.

Area C would be available for unrestricted use after removal of the contaminated materials. However, this area is not as desirable for development as higher ground in the vicinity.

Relocation of Ward Street should not create a significant disruption in the area, although relocation may have an impact on utilities and city planning. It could be relocated in this option because of road grade problems that might result if Ward Street were reestablished in its present location but at a higher elevation on top of contaminated material.

h) Cost Impacts

The cost of implementing this option would be greater than that of Option C but less than the cost of decontamination and restoration of the entire site. Cost would be an STA impact, if a perpetual care fund were included in the original cost.

i) Noise Impacts

Noise increase would be an STA impact during excavation, razing of the buildings, and stabilization. Operations would be conducted during daylight hours to minimize the impact.

j) Health Impacts

Excavation of Areas A and C could lead to external gamma exposure to workers that would be several times the annual exposure from natural background radiation. This exposure would be due to the high levels reported for radium concentration in the materials to be excavated.[2] A conservative estimate of the dose a worker could receive is 1 rem in 60 days during excavation of Area A, assuming an average contamination level of 900 pCi/g. During excavation and loading of contaminated materials from Area C, a worker could receive a dose of 1.5 rem in 30 days from contaminated materials averaging 2,500 pCi/g. These exposure rates would yield a cancer risk of 1×10^{-4} and 2×10^{-4} per year, or a total risk of 3×10^{-4} health effects per year maximum to an individual worker. Radon daughter inhalation risks are estimated to be 5×10^{-5} health effects per year. To limit individual exposures, it would be advisable to use different workers to excavate Areas A and C. These effects are considered to be STA impacts.

Upon completion of Option E, health effects to the nearby off-site population due to gamma radiation and radon at the site would be negligible. Radiation from most of Area A and from Area C would be at natural background levels after completion Option E. The remainder of Area A and Area B would be stabilized to reduce gamma radiation to natural background levels. Compacted soil or clay stabilization would be required to reduce radon emanation by an order of magnitude. Use of the site under these conditions would result in a minimal health impact, providing an LTB impact compared with Option A.

k) Safety Impacts

Decontamination to Criterion B involves the movement of 48,000 yd^3 of contaminated material from the site and 104,000 yd^3 of clean fill and stabilization materials to the site. Contaminated material could be moved by truck or rail from the site; the bases for accident statistics therefore are given in this section for both modes of transportation. During remedial action there will be an STA impact on safety.

In 1976, total rail freight traffic in the United States was 796 billion ton-miles,[6] with a corresponding 8,041 total accidents of which 6,328 were derailments,[7] yielding an incident frequency of 1.01×10^{-8} accidents of all types per ton-mile and 7.9×10^{-9} derailments per ton-mile. Based upon these statistics a maximum of 2 accidents would be predicted in transporting 48,000 yd^3 of contaminated materials 2,400 mi to the Nevada Test Site, if that facility were designated as a disposal site.

Total Interstate Commerce Commission (ICC) regulated motor carrier freight traffic in the United States for 1976 was 490 billon ton-miles.[7] The corresponding accident statistics were 25,666 accidents involving all materials shipped with 2,520 associated fatalities for an accident and fatality frequency of 5.24×10^{-8} accidents per ton-mile involving all materials shipped, and 5.14×10^{-9} fatalities per ton-mile. For example, using these statistics, 8 accidents and 0.8 fatalities are statistically possible while shipping 48,000 yd^3 of contaminated material to the Nevada Test Site and hauling 104,000 yd^3 of clean fill an average of 25 mi to the Canonsburg site.

According to the 1977 Bureau of Labor Statistics,[5] the injury incidence rate (including fatalities) for heavy construction work was 15.6 injuries per 100 full-time workers. Using this rate and the equivalent number of full-time workers on an annual basis, 3 job-related injuries might occur.

l) Transportation Network Impacts

If all contaminated and clean fill materials were hauled in trucks, there would be about 10,800 truckloads hauled to and from the site. This increased traffic would have an STA impact on local transportation networks for the estimated 120 working days required to implement Option E.

m) Employment Impacts

During implementation of this option there would be negligible overall impact on employment. Minor STA impact from loss of jobs by some employees at the industrial park would be offset by a minor STB impact resulting from new jobs required to conduct the remedial action. After completion of the remedial action there would be a potential for an LTB impact on employment with the possible redevelopment of Areas A and C.

n) Land Value Impacts

With unrestricted use of Area C and part of Area A, the value of these properties could rise to the market value in the area and could be sold by the government agency having responsibility for the site. The remainder of the stabilized areas would be retained by a governmental agency, and use of those areas for a roadway and a parking lot would not conflict with restricted use of the areas.

o) Aesthetic Impacts

An STA impact would occur during implementation as a result of the excavation and stabilization operations. Decontamination and restoration of some areas and stabilization of other areas would have an LTB impact on appearance of the site. Relocation of Ward Street would have little overall impact upon appearance of the site.

3.1.6 Option F - Decontamination and Restoration of Entire Site

Impacts of Option F during and after completion of the remedial action are summarized in Table 3-8. Option F involves razing the buildings and removal of contaminated materials to meet either of two decontamination criteria: (a) to 5 pCi/g of ^{226}Ra in the soil above natural radium concentration, or (b) to natural background levels of radium concentration in the soil. Following excavation, clean fill material would be placed on the site and the site would be revegetated. This option could not be implemented until a remote disposal site was selected and made ready to receive the contaminated material.

a) Mineral Resource and Soil Impacts

Efforts would be made to obtain the soil used for backfill from construction or excavation sites. If this source were available, there would be no impact on soil resources. If, however, the soil were obtained from a new excavation, there would be an STA impact at the source.

Removal of contaminated material from the site would reduce the ambient radiation levels and would result in an LTB impact compared with present conditions.

ORIGINAL (Red)

b) Ambient Radiation Impacts

Excavation of the contaminated materials could lead to minor increases in air particulate concentrations, including contaminated dust, and in small increases in radon concentrations at on-site and off-site locations during implementation of this option. By limiting the exposed working area and keeping the contaminated materials moist, dust and radon emanation would be minimized and increases in ambient radiation levels should be an STA impact on site and negligible off site. Continuous radiation monitoring would be used to detect any increases in ambient radiation levels so that corrective action could be taken.

Procedures that would prevent the spread of contamination by trucks or railcars hauling contaminated material from the site would be necessary. A washdown facility may be necessary to contain the contaminated materials. Such procedures are not necessary for the vehicles hauling clean fill to the site. However, dust control measures should be utilized during placement and grading.

Removal of contaminated material would reduce the gamma radiation and radon concentration to natural background levels and would result in an LTB impact compared with present conditions.

c) Ground and Surface Water Impacts

Exposing the contaminated materials during excavation makes them particularly vulnerable to water erosion from surface runoff and to leaching of contamination downward into the soil and ground water beneath the site. Construction of dikes between the contaminated area and Chartiers Creek would aid in preventing contaminated materials from reaching the river in the event of heavy precipitation during excavation. Limiting the exposed areas of contamination also would reduce the potential for severe erosion during a rainstorm and would reduce the area subject to leaching of contamination into ground water under the site.

Although these mitigating procedures should contain the contamination, there would be a potential for contamination of Chartiers Creek; therefore, excavation could result in an STA impact. Upon completion of the remedial actions under Option F, an LTB impact would result since the source of potential contamination would be removed.

d) Erosion Impacts

Water erosion was discussed in the previous paragraph. Wind erosion of contaminated material would be negligible because it would be limited by dust control procedures normally used in earthmoving operations. The backfilled area would be subject to erosion until vegetation became established. Such erosion could increase sediment loading in the local surface waters, but the sediments would not be contaminated. Therefore, the overall impact would be negligible.

e) Air Quality Impacts

Air quality would be degraded by exhaust fumes during implementation of the remedial actions, and negligible increases in dust and in radon emanation would be anticipated. The degradation of air quality would be an STA impact.

f) Biological Impacts

These impacts would be the same as those discussed previously. Again, flora and fauna presently on the site would experience an STA impact during remedial actions, but an LTB impact after completion of this option.

g) Land Use Impact

Upon completion of Option F the land would be available for unrestricted use and an LTB impact would result from the remedial actions.

h) Cost Impacts

The cost of Option F would be greater than the cost of the previous options and would be an STA impact.

i) Noise Impacts

During implementation of Option F, local noise levels from trucks and equipment would increase, producing an STA impact. All operations would be conducted during daylight hours, and proper equipment muffling and maintenance would assist in preventing excessive equipment noise.

j) Health Impacts

There would be STA impacts upon workers during excavation and removal of the contaminated material. In addition to a potential cancer risk of 6×10^{-5} health effects per year from radon daughter inhalation, calculations based on Appendix B show that a worker at the site could receive a radiation dose of up to 8 rem from external gamma radiation (this yields a cancer risk of 8×10^{-4} health effects per year) and up to 124 mrem (whole body) from dust inhalation. The worker would receive about 55 mrems from natural background gamma radiation during this same period of time (150 working days).

A truck driver hauling the contaminated material to a disposal site could receive a maximum of 3 rems from gamma radiation if he transported the radioactive material 8 hr per day for 75 days. These doses show that the STA impact during implementation of Option F would be significant due to the relatively high concentration of ^{226}Ra in the contaminated materials. A resident living along the transport route could receive radiation from the transportation process equivalent to 1/15 of the dose from normal background sources. These calculations are discussed in Appendix B.

Most radiation measurements near the site were slightly above natural background levels. Implementation of Option F would eliminate the site as a source of above-background radiation at off-site locations. Elimination of the present elevated gamma radiation and radon levels on site would result from removal of the contaminated materials at the site, and therefore would result in an LTB impact.

k) Safety Impacts

The potential for occurrence of industrial and traffic accidents during implementation of Option F would be greater than for the other remedial action options. During implementation of this option, an estimated 4 injuries to workers may occur.

Potential STA impacts associated with transportation of contaminated materials by both railroad and motor carrier have been calculated on the basis of shipping 200,000 tons of contaminated materials(1) between 100 and 2,400 mi, resulting in a total of 20 to 480 million ton-miles of shipping.

Based on railroad accident statistics, an estimated 0.2 to 5 accidents might occur during transportation of contaminated materials. Based on motor carrier statistics, during transportation of the contaminated materials by truck, 1 to 25 accidents and 0.1 to 2 fatalities might be predicted.

These accident risks from remedial action may be compared with the annual risk to the population and on-site employees of 6×10^{-2} health effects per year, or 3 potential cancer cases in 50 yr from the present site conditions.

l) Transportation Network Impacts

For decontamination of the site to the natural background level (Criterion B), about 10,400 truckloads of contaminated material would be hauled from the site. For decontamination to 5 pCi/g of radium above natural background (Criterion A), about 8,800 truckloads of contaminated material would be taken from the site. In addition an equal number of truckloads of clean backfill would be hauled to the site. This increase in traffic on public streets and roads would have an STA impact on the local transportation network for a period of up to 180 days. Coordination with local officials in obtaining proper route selection and traffic control could help to mitigate this impact. Transport of these materials by rail also would mitigate this impact.

n) Other Socioeconomic Impacts

Implementation of Option F would have negligible overall impact on employment, and an LTB impact if the restored area were redeveloped. There also would be an LTB impact on the land values of the site, since the site would be available for unrestricted use. During implementation of Option F there would be an STA impact on aesthetics similar to any construction or excavation project, but with the completion of restoration this impact would be eliminated.

In Chapter 4, advantages and disadvantages of the Options and their costs are presented.

TABLE 3-1

SUMMARY OF ENVIRONMENTAL IMPACTS RESULTING FROM OPTION A

Category of Impacts	Impacts of Present Conditions
Physical Impacts	
1. Mineral Resources and Soils	LTA
2. Ambient Radiation	LTA
3. Ground and Surface Waters	LTA
4. Erosion	LTA
5. Air Quality	LTA
Biological Impacts	
1. Flora	*
2. Fauna	*
Socioeconomic Impacts	
1. Land Use	LTA
2. Costs	NA
3. Noise	NA
4. Health	LTA
5. Safety	NA
6. Transportation Networks	NA
7. Employment	LTA
8. Land Values	LTA
9. Aesthetics	*

LEGEND
- LTB - Long-term beneficial impact
- LTA - Long-term adverse impact
- STB - Short-term beneficial impact
- STA - Short-term adverse impact
- NA - Not applicable
- * - Negligible impact

TABLE 3-2

RADON DAUGHTER HEALTH EFFECTS[a]
CANONSBURG SITE WORKERS

ORIGINAL (Red)

Building	Cancer Rate per Yr
1-Upper level	2.2×10^{-3}
1-Lower level	1.7×10^{-4}
2 & 2A	3.6×10^{-4}
3	9.2×10^{-3}
7	3.6×10^{-3}
9	2.3×10^{-3}
10	5.5×10^{-3}
11	1.1×10^{-4}
15	2.6×10^{-4}
16	3.4×10^{-3}
18-Upper level	5.8×10^{-4}
18 Lower level	2.1×10^{-4}
19	1.7×10^{-3}
Total Site	2.7×10^{-2}

[a] Lung Cancer

TABLE 3-3

EXTERNAL GAMMA HEALTH EFFECTS[a]
CANONSBURG SITE WORKERS

ORIGINAL (Red)

Building	Cancer Rate per Yr
1	3.9×10^{-4}
2 & 2A	8.9×10^{-5}
3	1.9×10^{-4}
7	5.5×10^{-4}
9	6.3×10^{-5}
10-Lower level	7.8×10^{-4}
10-Upper level	4.9×10^{-5}
11	1.8×10^{-6}
15	4.2×10^{-5}
16	2.3×10^{-4}
18-Upper level	6.3×10^{-5}
18 Lower level	8.3×10^{-5}
19	2.6×10^{-4}
Total Site	2.8×10^{-3}

(a) Leukemia

TABLE 3-4

SUMMARY OF ENVIRONMENTAL IMPACTS RESULTING FROM OPTION B

ORIGINAL (Red)

Category of Impacts	Impacts During Remedial Actions	Impacts After Completion of Option
Physical Impacts		
1. Mineral Resources and Soils	STA	LTA
2. Ambient Radiation	STA	LTA
3. Ground and Surface Waters	STA	LTA
4. Erosion	STA	LTA
5. Air Quality	STA	LTA
Biological Impacts		
1. Flora	*	*
2. Fauna	*	*
Socioeconomic Impacts		
1. Land Use	STA	LTA
2. Costs	STA	NA
3. Noise	NA	NA
4. Health	STA	LTB
5. Safety	STA	NA
6. Transportation Networks	NA	NA
7. Employment	*	LTA
8. Land Values	STA	NA
9. Aesthetics	STA	LTA

LEGEND
LTB - Long-term beneficial impact
LTA - Long-term adverse impact
STB - Short-term beneficial impact
STA - Short-term adverse impact
NA - Not applicable
* - Negligible impact

TABLE 3-5

SUMMARY OF ENVIRONMENTAL IMPACTS RESULTING FROM OPTION C

ORIGINAL (Red)

Category of Impacts	Impacts During Remedial Actions	Impacts After Completion of Option
Physical Impacts		
1. Mineral Resources and Soils	STA	LTA
2. Ambient Radiation	STA	LTB
3. Ground and Surface Waters	*	LTA
4. Erosion	*	LTB
5. Air Quality	STA	LTB
Biological Impacts		
1. Flora	STA	LTB
2. Fauna	STA	LTB
Socioeconomic Impacts		
1. Land Use	STA	LTA (Area A) LTB (Areas B&C)
2. Costs	STA	NA
3. Noise	STA	NA
4. Health	STA	LTB
5. Safety	STA	NA
6. Transportation Networks	STA	NA
7. Employment	*	LTA
8. Land Values	NA	NA
9. Aesthetics	STA	LTA (Area A) LTB (Areas B&C)

LEGEND
- LTB - Long-term beneficial impact
- LTA - Long-term adverse impact
- STB - Short-term beneficial impact
- STA - Short-term adverse impact
- NA - Not applicable
- * - Negligible impact

TABLE 3-6

SUMMARY OF ENVIRONMENTAL IMPACTS RESULTING FROM OPTION D

ORIGINAL (Red)

Category of Impacts	Impacts During Remedial Actions	Impacts After Completion of Option
Physical Impacts		
1. Mineral Resources and Soils	STA	LTA
2. Ambient Radiation	STA	LTB
3. Ground and Surface Waters	*	LTA
4. Erosion	*	LTB
5. Air Quality	STA	LTB
Biological Impacts		
1. Flora	STA	LTB
2. Fauna	STA	LTB
Socioeconomic Impacts		
1. Land Use	STA	LTA (Area A) LTB (Areas B&C)
2. Costs	STA	NA
3. Noise	STA	NA
4. Health	STA	LTB
5. Safety	STA	NA
6. Transportation Networks	STA	NA
7. Employment	*	LTA
8. Land Values	NA	NA
9. Aesthetics	STA	LTB

LEGEND

- LTB - Long-term beneficial impact
- LTA - Long-term adverse impact
- STB - Short-term beneficial impact
- STA - Short-term adverse impact
- NA - Not applicable
- * - Negligible impact

TABLE 3-7

SUMMARY OF ENVIRONMENTAL IMPACTS RESULTING FROM OPTION E

ORIGINAL (Red)

Category of Impacts	Impacts During Remedial Actions	Impacts After Completion of Option
Physical Impacts		
1. Mineral Resources and Soils	STA	LTA (Areas A&B) LTB (Area C)
2. Ambient Radiation	STA	LTB
3. Ground and Surface Waters	*	LTA (Areas A&B) LTB (Area C)
4. Erosion	*	LTB
5. Air Quality	STA	LTB
Biological Impacts		
1. Flora	STA	LTB
2. Fauna	STA	LTB
Socioeconomic Impacts		
1. Land Use	STA	LTB
2. Costs	STA	NA
3. Noise	STA	NA
4. Health	STA	LTB
5. Safety	STA	NA
6. Transportation Networks	STA	NA
7. Employment	*	LTB
8. Land Values	NA	LTB
9. Aesthetics	STA	LTB

LEGEND
- LTB - Long-term beneficial impact
- LTA - Long-term adverse impact
- STB - Short-term beneficial impact
- STA - Short-term adverse impact
- NA - Not applicable
- * - Negligible impact

TABLE 3-8

SUMMARY OF ENVIRONMENTAL IMPACTS RESULTING FROM OPTION F

Category of Impacts	Impacts During Remedial Actions	Impacts After Completion of Option
Physical Impacts		
1. Mineral Resources and Soils	STA	LTB
2. Ambient Radiation	STA	LTB
3. Ground and Surface Waters	STA	LTB
4. Erosion	*	LTB
5. Air Quality	STA	LTB
Biological Impacts		
1. Flora	STA	LTB
2. Fauna	STA	LTB
Socioeconomic Impacts		
1. Land Use	STA	LTB
2. Costs	STA	NA
3. Noise	STA	NA
4. Health	STA	LTB
5. Safety	STA	NA
6. Transportation Networks	STA	NA
7. Employment	*	LTB
8. Land Values	NA	LTB
9. Aesthetics	STA	LTB

LEGEND

LTB - Long-term beneficial impact
LTA - Long-term adverse impact
STB - Short-term beneficial impact
STA - Short-term adverse impact
NA - Not applicable
* - Negligible impact

CHAPTER 3 REFERENCES

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ORIGINAL
(Red)

CHAPTER 4

TRADEOFFS OF THE PROPOSED OPTIONS FOR REMEDIAL ACTION

CHAPTER 4

TRADEOFFS OF THE PROPOSED OPTIONS FOR REMEDIAL ACTION

Environmental tradeoffs involve a comparison of advantages and disadvantages of each option for remedial action in terms of its impacts. Tradeoffs also entail a consideration of land use, health, safety, and estimated costs for remedial actions at properties of concern. The advantages and disadvantages include consideration of impacts resulting from present conditions, those that may be incurred during implementation of remedial actions, and the potential impacts that could occur upon completion of the proposed remedial actions.

4.1 ADVANTAGES AND DISADVANTAGES OF THE PROPOSED OPTIONS FOR REMEDIAL ACTION

This tradeoff summary considers only the impacts of greatest magnitude. The major advantages and disadvantages of each option are listed in Table 4-1. A summary is given in Table 4-2 of the risks that have been quantified for radon and radon daughter inhalation, external gamma radiation, radioactive dust inhalation, industrial accidents, transportation of contaminated materials, and transportation of clean cover or fill. A summary of the option costs is available in Table 1-2, Chapter 1.

4.1.1 Option A - No Action

Option A is included so that the impacts of the present conditions can be compared with the impacts of the other options. The presence of radiation above natural background levels under the present conditions may have long-term impacts on employees at the site and to a lesser extent on the population, such as increased susceptibility to cancer. Any increase in future populations near the site will increase the incidence of cancer cases (the increase may be by a factor of 2, from 0.03 to 0.06 health effects per year). The presence of the contaminated materials on the site can lead to spread of contamination to adjacent properties and to Chartiers Creek. If the site were inundated to a significant extent, there would be some erosion of contaminated soils. This impact could be mitigated by remedial action.

4.1.2 Option B - Minimal Action

Fencing of the site would prevent its use and would eliminate health impacts to employees currently working in the Canonsburg Industrial Park; and it would be a low-cost option.

The major disadvantages would be that the potential for spread of contamination to adjacent properties and to surface and ground waters would remain. A governmental agency would acquire the site; and the industrial park could not be used, thereby eliminating its tax base. The buildings would deteriorate and could become an unattractive nuisance. A program of monitoring and maintenance would be required indefinitely.

4.1.3 Option C - Stabilization of All Areas without Removal of Buildings in Area A

Stabilization of the contaminated materials over the entire site and fencing of the developed area would eliminate exposure to employees by preventing access to the buildings. The stabilization cover would reduce the health impact due to external gamma radiation on site and radon daughter inhalation on site and off site to negligible values. The soil cover also would prevent surface erosion of contaminated materials by wind and rain. Areas B and C and part of A would be usable, but no excavation or construction of buildings would be allowed. The cost of this option would be moderate.

The disadvantages of this option are that part of Area A would not be usable for any purpose and that the buildings eventually would deteriorate. The contaminated materials remain in place with the potential for ground and surface water pollution. A monitoring and maintenance program to detect spread of contamination would be required indefinitely.

4.1.4 Option D - Stabilization of All Areas with Removal of Buildings in Area A

Razing of the buildings and stabilization of the site would allow restricted use of the entire site. This option would cost more than Option C but would leave the site in an aesthetically acceptable condition. The health impact of the site would be negligible in a fully stabilized condition.

The contaminated materials remaining on site would still constitute a potential impact for spread of contamination to ground and surface waters. The entire site would be unavailable for development and would remain under the control of a governmental agency. A monitoring and maintenance program would be required indefinitely.

4.1.5 Option E - Decontamination and Restoration of Part of Area A; Stabilization of Area B and Remainder of Area A; Decontamination and Restoration of Area C

Decontamination and restoration of Area C and the developed part of Area A would allow unrestricted use of those areas. Removal of contaminated materials from Area C would eliminate the main source for spread of contamination to ground and surface waters and erosion by flood waters. Area C and part of Area A would be available for commercial or industrial development, although Area C is not as desirable for such development. Area B and the remainder of Area A would be stabilized and could be used for relocation of Ward Street and for a parking area. These uses would be acceptable under the restricted use concept. This option would provide increased utility of the site compared with present conditions.

With contaminated materials remaining on site the potential for contamination of ground and surface waters remains, although the potential impact is significantly reduced with removal of contaminated materials from Area C. Full development of the entire site would not be allowed, as restrictions on the use of Area B and part of Area A would be in force. Monitoring and maintenance of the stabilized areas would be required indefinitely. The removal of contaminated materials from Area C could not proceed until a disposal site was selected and made ready to receive the material. The cost of transporting the contaminated materials could be high. The accident risk also would increase as the distance from Canonsburg to the remote disposal site increases.

4.1.6 Option F - Decontamination and Restoration of Entire Site

With complete decontamination and restoration of the site, the source of radiation and potential contamination would be removed to a disposal site. The entire Canonsburg site would be available for unrestricted use and the land value would increase. The land could be sold to private interests for development. No monitoring or maintenance program would be required. This option would provide the greatest assurance that no future risks would be incurred from contaminated materials at the site.

The disadvantages are the high cost, which could be many millions of dollars more than the site would be worth; and the accident potential, which could involve possible loss of life. Removal of contaminated materials from the site would be delayed until a disposal site was selected and made ready to receive the contaminated material.

4.2 SUMMARY AND DISCUSSION

Radiation levels on the site and in the buildings exceed the DOE proposed exposure guidelines for remedial action; therefore, the Canonsburg Industrial Park should not continue in operation permanently under present conditions.

Fencing the site and prohibiting access would reduce the health impact to employees in the industrial park but would not reduce the source of radiation to off-site locations, although the off-site health impact is minor.

Stabilization would reduce radiation levels sufficiently so that the site would have restricted use, and the off-site impact would be negligible.

Decontamination and restoration of part of the site with stabilization of the remaining area would allow use of the site to the extent that it is presently being used, at considerably less cost than the total decontamination option.

Decontamination and restoration of the total site would make it available for any use, but at a cost higher than present land values. Also the potential for injury and loss of life in traffic accidents and in industrial accidents during removal operations would be higher than the health impact of the site at present, as discussed in Chapter 3.

Contaminated material has been found at off-site locations in and around Canonsburg. Remedial action at the Canonsburg site would not affect elevated radiation levels at those locations. These materials and locations are to be evaluated and analyzed in separate reports.

4.3 COST-BENEFIT OF OPTIONS FOR REMEDIAL ACTIONS

Each of the options for remedial action has an associated number of health effects (cancer cases) that could be avoided as a result of the remedial action. The health effects avoided are those that could occur over and above the natural incidence of cancer and are attributable to the contaminated materials at the Canonsburg site. In particular, the contaminated materials are the source of radon and radon daughter inhalation and external gamma radiation. Risks from these sources and mechanisms of exposure are considered in presenting the cost-benefit of the remedial action (contaminated dust inhalation can be neglected).

The health effects avoided are the health effects that may be incurred by the present population living near the site and the employees working at the site. These risks were estimated to be 0.03 health effects per year for both groups (see Option A of Table 4-2), giving a total of 0.06 health effects per year that could be avoided. As a result of Option B, 0.03 health effects per year could be avoided by restricting employees from the site. As a result of Options C, D, E, and F, a total of 0.06 health effects per year could be avoided.

However, there are risks incurred by the workers during the implementation of each of the Options B through F. These risks reduce the health effects avoided. The health effects incurred are subtracted from the health effects avoided (mentioned above) to determine a net health effect avoided. The net health effect is used to determine cost-benefit ratio.

Health effects for an individual worker are listed in Table 4-2 for Options B through F. These values must be multiplied by the total number of workers estimated to be involved in the remedial actions (see Table 1-2, Chapter 1) to determine the total health effects that could be incurred for each option. By performing the multiplication, it will be noted that the potential total health effects incurred by workers involved in implementing Options B, C, and D are approximately 2×10^{-4}, 1×10^{-3}, and 2×10^{-3} health effects per year, respectively, from exposure to radiation. This gives a net health effect avoided of 0.03 for Option B and 0.06 for Options C and D. For Options E and F, the numbers of workers on site are estimated at 35 and 40, respectively (from Table 1-2). These numbers include truck drivers who haul clean soil as fill. However, until the disposal site is identified it is not possible to identify the number of drivers to haul the contaminated materials. Therefore, using only the number of workers shown in Table 1-2 in Chapter 1, risks as follows were estimated per decontamination criterion.

	Health Effects per Year	
Option	5 pCi/g	Background
E	1×10^{-2}	1×10^{-2}
F	3×10^{-2}	4×10^{-2}

The net health effects avoided for Option E are thus 0.05 for Criteria A and B and for Option F, 0.03 for Criterion A and 0.02 for Criterion B. The net health effects avoided can be expected to be smaller when the number of truck drivers hauling contaminated materials are included.

The net health effects avoided values as presented above are listed in Table 4-3 as a health benefit. The costs of the options are also shown (from Table 1-2) where the costs of Options E and F do not include transportation of contaminated material. The ratio of cost to health benefit is then listed. The ratio is noted to increase with increasing cost, whereas low cost-benefit ratios may be desirable. A cost-benefit ratio can be estimated that includes the risks to truck drivers, and the costs of hauling contaminated materials when a disposal site is identified. It is expected that these ratios will be higher than the ratios shown for Options E and F.

It is important to note also that injuries and fatalities might be incurred during implementation of Options B through F due to industrial and transportation mishaps (see Table 4-2). These potential factors may tend to negate the net health effects avoided as listed in Table 4-3, particularly in the case of Options E and F. Thus, the cost-benefit ratios listed in Table 4-3 must be used with care in noting trends.

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TABLE 4-1

ADVANTAGES AND DISADVANTAGES OF OPTIONS FOR REMEDIAL ACTION[a]

Option	Advantages	Disadvantages
A		1) Exposure to contamination on site remains unchanged
		2) Contamination remains permanently on site with potential for spread of contaminants
B	1) Low cost	1) Contamination remains permanently on site with potential for spread of contaminants
	2) Accomplished quickly	2) Public access permanently precluded
	3) Exposure to radiation minimized by limiting access	3) Governmental maintenance and semiannual surveillance required
C	1) Moderate cost	1) Contamination remains permanently on site with potential for ground water contamination
	2) Compacted clay cap would reduce radiation to background levels at surface	2) Areas B and C and part of Area A are available for restricted use only
	3) Areas B and C and part of Area A could be used for recreational purposes	3) Buildings unavailable for any use. Access prohibited
D	1) Intermediate cost	1) Contamination remains permanently on site with potential for ground water contamination
	2) Compacted clay cap would reduce radiation to background levels at surface	2) Site available for restricted use only

TABLE 4-1 (Cont)

Option	Advantages	Disadvantages
D (cont)	3) Entire site could be used for recreational purposes	3) Governmental maintenance and semiannual surveillance required
E	1) Area C and upper portion of Area A along relocated Ward Street available for industrial use	1) Contamination remains permanently on part of Area A and on Area B with potential for ground water contamination
	2) Remainder of Area A and Area B could be used for parking or recreational purposes	2) Lower portion of Area A and Area B would have restricted use, no building or excavation
	3) Major source of potential contamination of ground and surface waters removed (Area C)	3) Governmental maintenance and surveillance required for portion of site
	4) Less costly than Option F	4) Area C cannot be decontaminated and restored until a disposal site is available
		5) Potential high cost depending upon haul distance to disposal site.
F	1) Site decontaminated and restored	1) Potential high cost, depending upon haul distance to disposal site
	2) Removal of the source of potential health impacts	2) Larger potential for accidents
	3) Removal of source of potential radiological contamination	3) Delay in implementation until selection of a disposal site
	4) Site available for unrestricted use	

(a) Although Option A is not an option for remedial action, it is included in the table for comparison.

TABLE 4-2 SUMMARY OF QUANTIFIED RISK

HAZARD ↓ / OPTION →	A NO ACTION				B MINIMAL ACTION	C STABILIZATION	D RAZE BLDGS AND STABILIZATION	E PARTIAL DECONTAMINATION AND STABILIZATION							F DECONTAMINATION AND RESTORATION							
	INDIVIDUAL	POPULATION TOTAL	POPULATION EMPLOYEE	TOTAL	WORKER	WORKER	WORKER	WORKER	TRUCK DRIVER	RAIL-100 mi	RAIL-2400 mi	TRUCK-100 mi	TRUCK-2400 mi	TRUCK-25 mi	WORKER	TRUCK DRIVER	RAIL-100 mi	RAIL-2400 mi	TRUCK-100 mi	TRUCK-2400 mi	TRUCK-25 mi	
RADON & RADON DAUGHTER INHALATION H. E. PER YR.	2×10^{-5}	3×10^{-2}		3×10^{-2}	1×10^{-5}	2×10^{-5}	4×10^{-5}	5×10^{-5}							8×10^{-5}							5 pCi/g
								5×10^{-5}							7×10^{-5}							BKGD
EXTERNAL GAMMA RADIATION H.E. PER YR (m/REM)	1×10^{-5} (100)			3×10^{-3}	5×10^{-6} (60)	1×10^{-5} (100)	2×10^{-5} (150)	3×10^{-4}	1×10^{-4}						8×10^{-4}	3×10^{-4}						5 pCi/g
								3×10^{-4}	1×10^{-4}						9×10^{-4}	5×10^{-4}						BKGD
DUST INHALATION H. E. PER YR.								4×10^{-6}							1×10^{-5}							5 pCi/g
								5×10^{-6}							1×10^{-5}							BKGD
INDUSTRIAL ACCIDENTS					4×10^{-1}	1	2	3							4							5 pCi/g
								3							4							BKGD
TRANSPORTATION OF CONTAMINATED MATERIALS ACCIDENTS										6×10^{-2}	1	3×10^{-1}	7				2×10^{-1}	4	1	20		5 pCi/g
										7×10^{-2}	2	3×10^{-1}	8				2×10^{-1}	5	9×10^{-1}	25		BKGD
TRANSPORTATION OF CONTAMINATED MATERIALS FATALITIES													7×10^{-1}						9×10^{-2}	2		5 pCi/g
													8×10^{-1}						1×10^{-1}	2		BKGD
TRANSPORTATION OF CLEAN COVER OR FILL ACCIDENTS						1×10^{-1}	1×10^{-1}							2×10^{-1}							2×10^{-1}	5pCi/g
														2×10^{-1}							3×10^{-1}	BKGD
TRANSPORTATION OF CLEAN COVER OR FILL FATALITIES						1×10^{-2}	1×10^{-2}							2×10^{-2}							2×10^{-2}	5 pCi/g
														2×10^{-2}							3×10^{-2}	BKGD

TABLE 4-3

COST-BENEFIT RATIOS

Option	Health Benefit[a]		Cost of Option ($000)		Cost-Benefit Ratio ($ Per Health Benefit)	
B	0.03		200		7×10^6	
C	0.06		760		1×10^7	
D	0.06		1,215		2×10^7	
	5 pCi/g[b]	Bkgd[b]	5 pCi/g[b]	Bkgd[b]	5 pCi/g[b]	Bkgd[b]
E	0.05	0.05	1,525[c]	1,620[c]	3×10^7	3×10^7
F	0.03	0.02	2,245[c]	2,468[c]	7×10^7	1×10^8

[a]Net Health Effect avoided.

[b]For Options E and F, values for each decontamination criterion, 5 pCi/g above background and background (Bkgd), are given.

[c]Costs for Options E and F do not include transportation costs for contaminated material.

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APPENDIX A

GLOSSARY

GLOSSARY

Terms/Abbreviations	Definitions
absorbed dose	Radiation energy absorbed per unit mass.
aesthetics	Pertains to that which is pleasing to the visual senses; an attitude that is usually individually subjective.
alpha particle (α)	A positively charged particle emitted from certain radioactive materials. It consists of two protons and two neutrons, hence is identical with the nucleus of the helium atom. It is the least penetrating of the common radiations (α, β, γ), and is not dangerous unless alpha-emitting sustances have entered the body.
ambient radiation level	The existing radiation level at a given location at a specific time or time period. Ambient levels reflect radiation from contaminated material in addition to natural background radiation.
aquifer	A water-bearing formation below the surface of the earth; the source of wells. A confined aquifer is overlain by relatively impermeable rock. An unconfined aquifer is one associated with the water table.
background radiation	Naturally occurring low-level radiation to which all life is exposed. Background radiation levels vary from place to place on the earth.
beta particle (β)	A particle emitted from some atoms undergoing radioactive decay. A negatively charged beta particle is identical to an electron. A positively charged

	beta particle is called a positron. Beta radiation can cause skin burns and beta emitters are harmful if they enter the body.
endangered species	A species whose survival is in jeopardy. Its peril may result from destruction of habitat, change in habitat, over-exploitation by man, predation, adverse interspecific competition, disease, or because an area is at the edge of its geographical range. An endangered species must receive protection, or extinction probably will follow.
dose equivalent	A term used to express the effective radiation dose when modifying factors have been considered (the numerical product of absorbed dose and quality factor).
external gamma radiation	Gamma radiation emitted from a source(s) external to the body, as opposed to internal gamma radiation emitted from ingested or inhaled sources.
exposure	Magnitude of radiation to which a person is subjected. It is defined as the measured electrical charge produced per unit mass of air.
exhalation	Emission of radon from earth (usually thought of as coming from a uranium tailings pile, but actually from any location).
fauna	Animal life including mammals, birds, fish, reptiles.
fixed alpha	Particulate alpha-emitting isotopes which have become imbedded in otherwise nonradioactive surfaces and which cannot be removed by standard decontamination techniques.

flora	Plant life, both land and aquatic species.
gamma background	Natural gamma ray activity everywhere present, originating from two sources: (1) a cosmic radiation component, and (2) terrestrial radiation. Whole body absorbed dose equivalent in the U.S. due to natural external gamma radiation from both sources ranges from about 60 to about 125 mrem/yr.
gamma ray (γ)	High energy electromagnetic radiation emitted from the nucleus of a radioactive atom, with specific energies for the atoms of different elements and having high penetrating power.
ground water	Subsurface water in the zone of full saturation which supplies wells and springs.
half-life	The time required for one-half of the radioactive atoms present at any given time to decay with emission of radiation.
impact	The effect brought about by a proposed action to alter an existing condition; an impact may be adverse or beneficial.
Interim Drinking Water Standards	Title No. 40 of the Code of Federal Regulations, Chapter 1, Part 141, dated Dec 24, 1975; became effective June 24, 1977.
isotope	One of two or more species of atoms with same atomic numbers (the same chemical element) but with different atomic weights. Isotopes usually have very nearly the same chemical properties, but somewhat different physical properties.
manrem	A unit used in health physics to compare the effects of different amounts of radiation on groups

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of people. It is obtained by multiplying the average dose equivalent to a given organ or tissue (measured in rems, which see) by the number of persons in that population.

μR/hr — Microroentgen per hour (10^{-6}R/hr)

mR/hr — Milliroentgen per hour (10^{-3}R/hr)

maximum permissible concentration — The highest concentration in air or water of a particular radionuclide permissible for occupational or general exposure without taking steps to reduce exposure.

pCi/l — Picocurie per liter (10^{-12}Ci/l).

pCi/g — Picocurie per gram (10^{-12}Ci/g).

pCi/m^2-s — Picocurie per meter squared-second (10^{-12}Ci/m^2-sec)

quality factor — An assigned factor which denotes the modification of the effectiveness of a given absorbed dose by the linear energy transfer.

rad — The basic unit of absorbed dose of ionizing radiation. A dose of 1 rad means the absorption of 100 ergs of radiation energy per gram of absorbing material.

radioactivity — The spontaneous decay or disintegration of an unstable atomic nucleus, usually accompanied by the emission of ionizing radiation.

radioactive decay chain — A succession of nuclides each of which transforms by radioactive disintegration into the next until a stable nuclide results. The first member is called the parent, the intermediate members are called daughters, and the final stable member is called the end product.

radium — A radioactive element, chemically similar to barium, formed as a daughter product of uranium (^{238}U). The most common isotope of radium, ^{226}Ra, has a half-life of 1,620 yr. Radium is present in all uranium-bearing ores. Trace quantities of both uranium and radium are found in all areas, contributing to the gamma background.

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radon — ^{222}Rn, a radioactive, chemically inert gas, having a half-life of 3.8 days; formed as a daughter product of ^{226}Ra.

radon background — Low levels of radon gas found in an area, due to the presence of radium in the soil.

radon concentration — The amount of radon per unit volume. In this assessment, the average value for a 24-hr period of atmospheric radon concentrations, determined by collecting data for each 30-min period of a 24-hr day and averaging these values.

radon daughter — One of several short-lived radioactive daughter products of radon (several of the daughters emit alpha particles).

radon daughter concentration — The concentration in air of short-lived radon daughters, expressed usually in pCi/l; also measured in terms of the working level (WL).

radon flux — The quantity of radon emitted from a surface in a unit time per unit area (typical units are in pCi/cm^2-s).

rare species — A rare species is not currently threatened with extinction, but it occurs in such small numbers that it may become endangered if its environment deteriorates further or other limiting factors are altered. Continued observation of its status is essential.

recharge — The process by which water is absorbed and added to the zone of saturation of an aquifer, either directly into the formation or indirectly by way of another formation.

roentgen (R) — A unit of exposure to ionizing radiation. It is that amount of gamma or X-rays required to produce ions carrying 1 electrostatic unit of electrical charge, either positive or negative, in 1 cubic centimeter of dry air under standard conditions (numerically equal to 2.58×10^{-4} coulombs/kg).

rem — The unit of dose equivalent of any ionizing radiation which produces the same biological effect as a unit of absorbed dose of ordinary X-rays, numerically equal to one rad of absorbed dose multiplied by the appropriate quality factor for the type of radiation. The rem is the basic recorded unit of accumulated dose to personnel.

socioeconomic — Pertaining to and affecting society and the economy in a general way or to smaller parts as within one area.

transferable alpha — Particulate alpha-emitting isotopes, found on surfaces usually in the form of dust, which can be removed from the surface by dry or wet wiping using the smear technique.

undetermined species — A species whose status is undetermined may be either rare or endangered, but currently available information is inadequate to determine its status accurately. More information is needed to determine if the species now exists in dangerously low numbers.

working level (WL)

A unit of radon daughter exposure, equal to any combination of short-lived radon daughters in 1 liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha energy. This level is equivalent to the energy produced in the decay of the daughter products RaA, RaB, RaC, and RaC' that are present under equilibrium conditions in a liter of air containing 100 pCi of ^{222}Rn. It does not include decay or RaD (22-yr half-life) and subsequent daughter products.

working level month (WLM)

One WLM is equal to the exposure received from 170 WL-hours.

APPENDIX B

POTENTIAL HEALTH IMPACTS

APPENDIX B

POTENTIAL HEALTH IMPACTS

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Potential health impacts (cancer cases) have been estimated for the Canonsburg site. The methodology and parameters used in the analysis are contained in this appendix. Measured radiation data are from ORNL.(1)

B.1 HEALTH EFFECTS FROM CONTINUAL RELEASES

Inhalation of radon daughters, external gamma exposure, and ingestion of contaminated vegetation are the major exposure mechanisms quantified in this analysis.

The basic equation used to obtain the individual health effect risk from radon daughter inhalation is given in the equation:

$$R_l = CUf_tK_r \qquad \text{(B-1)}$$

where:

R_l = annual individual risk for lung cancer from the radiation (yr^{-1})

C = radon daughter concentration (WL)

U = conversion of WL to $\frac{WLM}{yr}$ for continuous occupancy (50)

f_t = occupancy factor (dimensionless)

K_r = risk estimator (1.8×10^{-4} per yr per WLM/yr)

The expression for the individual annual cancer risk from external gamma exposure is:

$$R_c = Df_tK_g \qquad \text{(B-2)}$$

where:

R_c = annual individual risk for cancer from radiation (yr^{-1})

D = gamma dose rate (rem/yr)

K_g = risk estimator (1×10^{-4}/yr per rem/yr)(2)

The expression for the annual cancer risk from ingestion of contaminated material is:

$$R_i = C_rf_rU_iK_i \qquad \text{(B-3)}$$

where:

R_i = annual individual risk for cancer from the ingested material (yr^{-1})

C_r = concentration of contaminant in the soil (pCi/g)

f_r = plant transfer function (pCi/g vegetation per pCi/g soil)

U_i = usage factor (g vegetation ingested/yr)

K_i = risk estimator (cancers/yr per pCi/yr ingested)[2]

The parameters f_r and U_i were obtained from Reference 3.

The expression for dose rate to individuals from exposure to radioactive dust is:[4]

$$D = C\ K\ U_a\ T_x\ f\ (DF)_m \tag{B-4}$$

where:

D = dose rate (mrem/yr)

C = concentration of isotope in the contaminated material (pCi/g)

K = dust loading in the air (5×10^{-4} g/m^3)

U_a = breathing rate of exposed indivduals (0.91 m^3/hr)

T_x = time period of exposure (hr)

f = average to maximum concentrations of ^{226}Ra in site soil, taken as f = 1

$(DF)_m$ = dose rate conversion factor for ^{226}Ra

The total cancer rate, CR, is obtained by multiplying the individual risk given in the above equations by the number of people at risk, P.

B.1.1 Health Effects from Canonsburg Industrial Park Contamination

As an example, the health risk to workers inside Building 3 from radon daughter inhalation was calculated from equation (B-1) with the following parameters:

C = 0.43 WL

f_t = 40 hr/wk = 0.24

P = 10 equivalent people

Individual risk to the occupational personnel is as follows:

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$$R_1 = CUf_t K_r = (0.43)\ (50)\ (0.24)\ (1.8 \times 10^{-4})$$

$$= 9.2 \times 10^{-4}/yr$$

The Pennsylvania average lung cancer risk from all causes is 4.7×10^{-4}/yr.[5,6]

The projected cancer rate CR is obtained by multiplying the individual risks listed above by the number of people exposed to these risks:

$$CR = 9.2 \times 10^{-4}\ (10)$$

$$= 9.2 \times 10^{-3}/yr$$

The CR to the workers in Building 3 from external gamma radiation, obtained in a similar fashion is:

$$CR = 1.9 \times 10^{-4}/yr$$

B.1.2 Population Health Effects

A soil sample taken from a garden east of Strabane Avenue had a ^{226}Ra concentration of 110 pCi/g. Ingestion of radioactive vegetables from this garden may be estimated from equation (B-3) where:

C_r = 110 pCi/g

$f_r = 3 \times 10^{-4}$

$U_i = 2 \times 10^5$ g vegetables/yr

$K_i = 3 \times 10^{-7}$ cancers/yr-pCi/yr

$R_i = C_r\ f_r\ U_i\ K_i = 2 \times 10^{-3}/yr$

The risk is the same whether the vegetables are consumed by one person or by many persons.

External gamma measurements along Latimer Avenue, south of the Canonsburg Industrial Park, averaged 22 μR/hr, or twice the natural background level. The increased individual risk associated with this gamma radiation exposure can be calculated from equation (B-2) to be 9.6×10^{-6} cancers per year. The population risk can be obtained by multiplying the individual risk by the number of people residing on Latimer Avenue across from the industrial park.

Since the highest off-site radioactive measurements were found along Latimer Avenue, the risk at other areas will be smaller than to the residents along Latimer Avenue.

An off-site measurement of radon concentration in the prevailing wind direction gave a value of 0.82 pCi/l at a distance of about 1,000 ft from the site.[7] Measurements 400 ft from the site in other directions averaged 0.5 pCi/l.

Risk to the population was calculated by assuming that 1,200 people were exposed to 0.5 pCi/l above natural background radon concentration and that 800 people were exposed to 0.2 pCi/l above natural background radon concentration all the time. Equation (B-1) was used to determine the individual risk. The population risk is:

$$CR = (0.027 + 0.007)yr^{-1} = 0.03\ yr^{-1}$$

B.2 HEALTH EFFECTS ASSOCIATED WITH REMEDIAL ACTION

Examples of quantifying exposure risks from inhalation of radon daughters, external gamma radiation, contaminated dust, gamma radiation during transport, and exposure to a resident along a transportation route are given in the following paragraphs.

B.2.1 Occupational Exposure

Workers involved in the remedial actions will be exposed to radiation. Following are estimates of the risks involved from radon daughters, external gamma, contaminated dust, and gamma radiation during transport.

Radon Daughter Inhalation

Outdoor measurements of radon[1,7] on site indicated a range of values up to 17 pCi/l. A value of 10 pCi/l is assumed to be representative of the average outdoor radon concentration for the site. This value is used to estimate the radon and radon daughter inhalation health risk to the individual worker involved with remedial actions. If the assumed concentration outdoors is constant over time until the contamination is removed from the site through Option F (a conservative assumption considering changing wind conditions) and using 200 pCi/l ^{222}Rn as equal to 1 WL (assuming 50% equilibrium for radon and its daughters), the following estimates are obtained using equation (B-1):

Option	f_t	R_1 (Health Effects/Yr)
B	0.027	1×10^{-5}
C	0.055	2×10^{-5}
D	0.082	4×10^{-5}
E	0.110, 0.118	5×10^{-5}, 5×10^{-5}
F	0.137, 0.164	6×10^{-5}, 7×10^{-5}

The two values for Options E and F correspond to the two different working days to decontaminate to Criterion A and to Criterion B.

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External Gamma Exposure

Workers that would perform the remedial actions for Options B, C, and D would receive an estimated exposure of 50, 100, and 150 mrem, repsectively, or less from external gamma radiation. These values are based on an estimate of an average of 200 μR/hr external gamma radiation at 1 m above the surface on site for 30, 60, and 90 working days for Options B, C, and D, respectively. The averages for 86 ORNL external gamma measurements along the proposed fence lines and for 308 measurements[1] over the three parcels of land were 140 and 160 μR/hr, respectively. These values are 129 and 149 μR/hr above background. The 200 μR/hr used above is therefore a conservative estimate. The estimated individual worker exposure yields cancer risks of 5×10^{-6}, 1×10^{-5}, and 2×10^{-5} health effects per year for Options B, C, and D, respectively, using equation (B-2).

Gamma Exposure

Gamma exposure to workers involved in site cleanup is given by the following relationship.[8]

$$D_r = 2.5\ C_{ra}$$

where:

D_r = exposure rate in μR/hr

C_{ra} = radium concentration in pCi/g

Using Criterion A, in the case of Option E part of Area A and all of Area C are to be decontaminated by excavating and removing the contaminated materials. Assuming it takes 60 days to decontaminate Area A which is assumed to be of an average contamination level of 900 pCi/g of radium, an individual worker would receive a dose of 1 rem yielding a cancer risk of 1×10^{-4} health effects per year. For Area C it is assumed that the average contamination level is 2,500 pCi/g and it takes 30 days to do the decontamination. These assumptions result in a dose of about 2 rem to a worker or a cancer risk of 2×10^{-4} health effects per year. The above estimates are essentially the same for Option E using Criterion B as the level of decontamination.

A conservative estimate of the worker exposure time during cleanup of the total site, Option F, is 150 working days.[9] The average estimated concentration of the debris in the site, was assumed from the bore hole measurements to be 2,500 pCi/g.[1] These values give a radiation dose of 8 rem to the worker. The individual risk is 8 x 10^{-4}/yr. During that same 150 working days (210 calendar days), workers will be exposed to 55 mrem from natural background gamma radiation (11 μR/hr).[1]

Exposure from Dust

Radiation exposure to workers from breathing contaminated dust during the excavation operation can be calculated from equation (B-4) using the data already listed and the dose conversion factor for ^{226}Ra.[3] The dose to the individual worker is 124 mrem for an exposure of 1,200 hr (150 working days). A radium concentration of 2,500 pCi/g (approximately 1% U_3O_8) was assumed for the contaminated material. Using this approach, 43 and 48 mrem were obtained for Option E, Criteria A and B respectively; and 150 mrem for Option F, Criterion B.

Transportation Exposure

Truck drivers will be exposed to gamma radiation as they move the contaminated material from the Canonsburg site. The dose rate for the truck drivers from gamma radiation is the same as that for the worker at the Canonsburg site except that the steel in the truck attenuates the effect. As a conservative estimate it was assumed that the drivers were transporting the contaminated material half of the time for the 150 days allotted to clean up and restore the site. The steel in the truck was assumed to reduce the radiation to the driver by 20%. These values give a radiation dose to an individual truck driver of 3 rem with an attendant cancer risk of 3 x 10^{-4}/yr.

B.2.2 Dose to a Nearby Resident During Transportation

A person living adjacent to the route used to transport contaminated material from the site may receive some gamma radiation from the trucks passing the homes and from the small amount of contaminated material lost from the trucks. The following equation derived at FB&DU was used to calculate the exposure to the observer.

$$O_d = 5 \times 10^{-2} \frac{R}{r} \left[\frac{1}{v} + f_\ell \frac{T}{L}\right] \qquad \text{(B-5)}$$

where:

O_d = observer dose (mrem)

R = total radium content in soil (4.2 x 10^{14} pCi)

r = distance bewteen resident and the road (10^3 cm)

v = velocity of truck (30 mph = 4.8 x 10^6 cm/hr)

f_ℓ = fraction of load lost from truck (10^{-5})

T = total transport time (180 days = 1.44×10^3 hr)

L = distance of transport (1 mi = 1.6×10^5 cm)

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The dose to a nearby resident was calculated from (B-5) to be 6.3 mrem. The associated risk to the resident is 6.3×10^{-7}/yr.

Although the calculations were carried to two or three figures, the resulting exposure estimates should be interpreted as valid only to one significant figure, with an overall accuracy of approximately a factor of 2.

APPENDIX B REFERENCES

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